Safety element, city of Moorpark. Vols. 1 & 2. [1988?]

1988

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SAFETY ELEMENT

VOLUME I

Safety Element Vol. I & II

I hereby certify, under penalty of perjury, that the following is a true and correct copy of the element adopted by the City Council of the City of Moorpark, on 1-7-87 by Reso. 87-364.

Dated: 2-16-88

Maureen W. Wall

City Clerk of the City of Moorpark, California

(Seal)

CITY OF MOORPARK CALIFORNIA INCORPORATED JULY 1, 1983

Safety Element

CITY OF MOORPARK

JSA

gives good background data for evaluation and discussion of the various hazards that affect the City of Moorpark and as such, has been included to provide the necessary supplement to the more detailed analysis of the City hazards themselves.

New information was necessary to update certain sections of the County text. This new data was originally generated in a number of ways. One of the first were Seismic Hazard Studies that are part of an ongoing effort to upgrade the comprehensive view of hazards in the southern and selected northern portions of Ventura County. These studies were started by a cooperative hazard study instituted between the County and the State Division of Mines and Geology in 1974. The result was a Seismic Hazards Study of Ventura County and in 1975, an open file report 76-5-LA was prepared by the California Division of Mines and Geology in cooperation with the County of Ventura. A number of factors were evaluated and new data generated by that report and the results of that report have been included within the Moorpark Safety Element.

An ongoing process by the State of California has been to evaluate each of the possibly significant faults in the State, to determine whether or not those should be included within the Alquist-Priolo Seismic Hazard Zones which are designated along each of the active faults within the State of California. A number of faults and fault segments have been evaluated in the County over the last twelve (12) years and the results of those

evaluations have also been included in the City Element.

As part of the general review of the background information and discussions with the County staff, the author determined that the groundwater conditions had changed fairly radically within the City over the last ten (10) years. That information was further researched, including some primary research on watertable levels. These new water levels were mapped and that information is also included within the relevant sections.

Another area that was done basically from scratch for the Moorpark Safety Element was the local discussions of the hazards under each of the hazard sections. These were prepared for the County of Ventura and each of the then nine (9) cities in 1974 and new discussions have now been prepared for each of the relevant hazards in the City of Moorpark.

The County Element contained a number of sections which have no bearing on the City and those sections were deleted from the Moorpark Safety Element. The remainder of the County Elements were retained and updated as necessary.

Fault Displacement Hazard -- This section includes new data on the Simi-Santa Rosa Fault and its potential activity.

Groundshaking Hazard -- A local discussion was prepared, but no futher mapping was deemed necessary as no more detailed data was available.

Liquefaction Hazard -- The new and changing groundwater data required a complete reevaluation of this hazard and new primary mapping for the Moorpark area. The results included a potentially threatening increase in groundwater levels in the near future within the City which could increase this hazard noticeably.

Flooding -- Channel improvements and more detailed analysis by the County and Federal governments have concluded that the Flooding Hazard, that is, the 100 year flood plains within the City, have actually been reduced in area and new maps have been prepared. A new description has been included within the Element.

Landslide/Mudslide Hazard areas have been identified for particular areas in the City and new maps have been prepared. Also, detailed hazard areas within the City have been described.

Expansive Soils -- Although this hazard is mitigatable during construction; for comparison purposes and for use by the City staff, a detailed hazard plate has been prepared for expansive soils covering the entire area of interest of the City.

Dam Inundation -- The Dam Inundation Hazard was not included within the 1974 Safety Element for the County, since three of the key dams affecting the County area had not prepared Dam Inundation maps at the time that Element was published. The

County has not subsequently updated their Element to include this section which is required by State Planning and Zoning Law. A new section has been prepared for this Element which is both a general discussion of the hazard throughout the County for Volume II and the more detailed discussions of the hazard in Moorpark for this volume. However, a map was not prepared, due to the sensitivity of the data.

Fire -- Fire basically affects the hillside areas that retain natural vegetation throughout the City. A local discussion was prepared. However, no further mapping was deemed necessary.

It is the hope of the author that the Element will be useful to the City, both for illustrative purposes and as an ongoing reference data base for evaluating projects and potential land uses. The maps have been prepared, both at a reduced scale for inclusion within the Element and at the base 2,000 scale, the same scale the other City General Plan Elements have been prepared at and will be available as a resource for the City.

Generally, the City of Moorpark is in a very favorable position in regard to natural hazards as compared to other portions of the County and other areas of Southern California. In terms of earthquake hazards, only two (2) small potentially active faults with a low probability of displacement are found within the City area and the secondary effects of ground shaking are much less than are found on the Oxnard Plain. The flood hazard to the City

has been much reduced in the last few years. The fire hazard produced by the coastal sage/grasslands surrounding the City is less severe than areas that have heavy chaparral vegetation. Therefore, the City appears to be a safer place to live than other communities in the area.

FAULT DISPLACEMENT

A fault is a zone of weakness or movement in the earth's crust. The earth's surface materials are laced with faults, all different rock formations and all areas have faults. Most of these faults have not moved for hundreds of thousands or even millions of years and thus, can be considered inactive. Others, however, show evidence of current (within the last 11,000 years) activity or have moved recently enough to be considered active, i.e., capable of displacement in the near future. Any fault movement beneath a building in excess of an inch or two could severly damage the structure, depending on its design and construction and the shaking stresses it experiences at the same time.

Most faults exist in fault zones, i.e., areas in which a number of individual fault traces exist. Any fault movement would be along a particular fault trace, the actual movement along which is unpredictable at the present time. Outside of the fault zone itself, there is no more hazard than there would be having a building located miles away from the fault. Therefore, the hazard is extremely localized within a particular fault zone. Further, even the most active fault presently known, i.e., the San Andreas Fault which is located north of Southern California, moves only the average of once every 135 years and then only along one of many parallel traces.

Therefore, this hazard is extremely localized within a narrow fault trace. Secondly, the hazard zone is designed only along active faults, i.e., those faults which have shown evidence of moving within recent times. Thirdly, this hazard has a very low probability of occurrence within the lifetime of any structure.

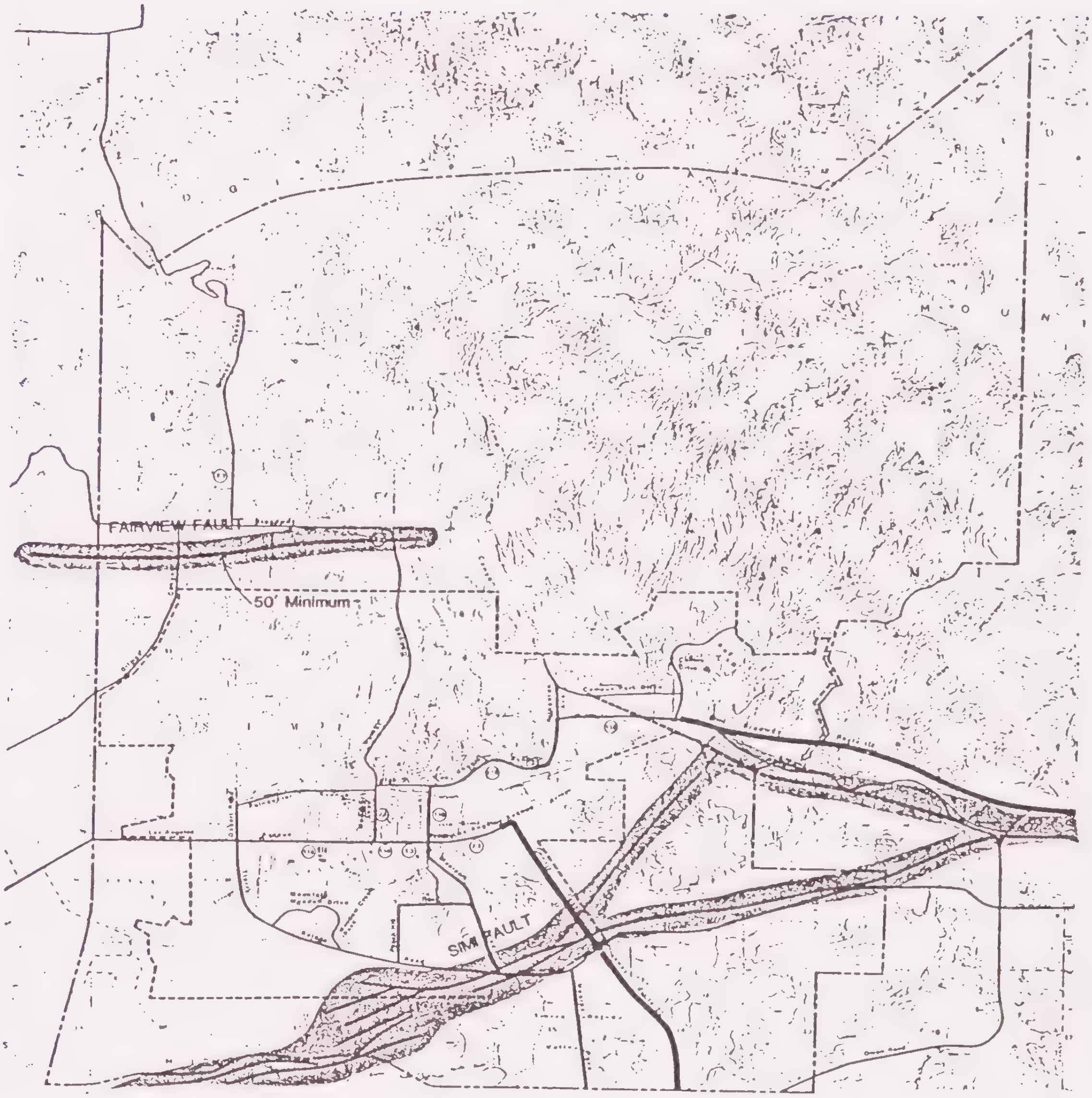
Within the City of Moorpark, only the Simi/Santa Rosa Fault shows a high probability of being what is considered an active fault under the State Special Studies Zones Criteria which would, if applied, require further studies for projects in the zone. Studies are presently being undertaken to determine whether or not this fault has moved within the last 11,000 years which would designate it as an active fault under State Special Studies Zone definition. It affects the area immediately north of the Tierra Rejada Valley and near the intersection of Tierra Rejada and Moorpark Roads. A fault hazard zone as indicated on Moorpark Safety Plate I, has been delineated along this fault, a minimum of 50 feet from the probable surface trace. This delineation is for study purposes so that any structure proposed within the area could have a thorough geologic examination to determine where the fault is and a reasonable setback to minimize any potential hazard. The fault itself is very narrow but the hazard zone is much wider and the minimum 50 feet wide zone is not to scale on Moorpark Safety Plate I.

Another fault trace worthy of further study is located in the Fairview area, but no particular structures or proposed developments are directly affected. That is also indicated on Moorpark Safety Plate I by a hazard zone.

Fault displacement is a relatively minor hazard with a very low probability of occurence, especially within the City of Moorpark.

POLICY

Large structures or subdivisions of more than four units shall prepare geology reports to locate any surface trace of the Simi and Fairview Faults and to designate appropriate setback distances from the surface traces of those faults, to be a minimum of 25 feet, unless otherwise required by a geology report.



LEGEND

Faults Identified

Faults Conjectural

Hazard Area Min 50' From Center Of Fault

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE I

Fault Displacement

CITY OF MOORPARK

EARTHQUAKE AND GROUND SHAKING

Along with Fault Displacement and ground shaking, earthquakes produce a number of other secondary effects such as liquefaction which is the liquifying of the surface materials which can cause structural failure. Landsliding can be caused by ground shaking induced by earthquakes and affects predominantly hillside areas. Both of these hazards are covered as separate hazards in the Safety Element.

By far, the greatest damage done by an earthquake is caused by the ground shaking, not the fault displacement. California is interlaced with hundreds of active faults. The most important system is the San Andreas Fault which extends from south of Los Angeles to north of San Francisco. The main branch of this fault runs through the extreme northeastern corner of Ventura County. This fault is responsible for at least two major earthquakes; the San Francisco earthquake of 1906 and the Fort Tejon earthquake of 1857. The earthquake of 1857 is reported to have caused severe shaking in the, then largely undeveloped, southern portion of Ventura County.

When a fault breaks, all of the accumulated strain energy is released as seismic waves. These waves travel outward in all directions from the earthquake focus. These waves cause the

ground shaking that is experienced from an earthquake. The shaking affects buildings in different ways. In general, research of many past earthquakes indicate that the intensity of ground shaking at a given location during an earthquake is a function of several factors including:

1. Magnitude of the earthquake.

2. Distance from the center.

3. Depth from which the earthquake was generated.

4. Type of ground motion.

5. Geologic structure.

6. Type of ground.

Of these, the only variable which can assessed accurately in advance, is the type of ground. Determination of ground response (ground wave) can be estimated based upon the existing earthquake records, though only for a predetermined location and magnitude of an earthquake. The intensity of ground shaking during an earthquake depends, in large part, upon the geologic foundation conditions, i.e., the thickness and physical properties of material comprising the upper several hundred feet beneath the area. In general, the greatest amplitude and longest duration of

ground shaking usually occurs on thick water saturated unconsolidated alluvial sediments.

The earthquake waves consist of two basic types which have different affects on structures. Waves with long period amplification affects tall structures predominantly and have a lesser affect on single family dwellings. Short period amplification waves have the greatest affect on small structures such as small businesses, single family dwellings and small apartment units.

Generally, the valley floor of the main City area in Moorpark would have a slight to moderate amplification of long period waves and would have the greatest hazard to large structures such as major industrial buildings or high rise structures. The greatest amplification of short period waves occurs near the hillside areas where the alluvial material is much thinner just before you start to climb the hills. The lowest amplitude of either long or short period waves is located in the hillside areas where there is a very small distance to the bedrock surface.

The San Andreas Fault provides the greatest threat of earthquake to Moorpark and to most of the remainder of Southern California. Moorpark is no more susceptible than any other city in the County of Ventura to shaking from a probable earthquake on the San Andreas Fault.

POLICY

Developments of over 4 units, either multiple family or individual home subdivisions or structures over 20,000 square feet shall be reviewed for consistency with the Uniform Building Code. Soils reports shall be prepared which discuss the magnitude of earthquake shaking and include specific information pretaining to vertical and horizontal maximum acceleration that could be expected at the site. A special section in addition to the minimum requirements shall be required to determine if the particular site is more or less susceptible to long or short period horizontal and vertical ground acceleration and make suggestions for possible mitigation if necessary.

LIQUEFACTION

As discussed in the previous chapter, by far, the greatest threat from an earthquake is the ground shaking that is produced and the resulting direct and indirect affects on manmade structures. In some earthquakes, ground shaking results in complete ground failure which could have catastrophic affect on structures. Ground failure is mostly caused by liquefaction and can occur on relatively level ground.

Liqufection can occur when loose cohesionless uniform soils are saturated with water and subjected to ground shaking of high enough intensity and long enough duration. Liquefaction is manifested by either the formation of sand boils and mud spouts at the ground surface and the seepage of water through open cracks or in some cases, by the development of quicksand like conditions over substantial areas. When the quicksand like conditions occur, buildings may sink substantially or tilt into the ground and buried facilities may float to the surface. Other manifestations are landslides which can move hundreds of feet or in lateral earth spreading of tens of feet.

The conditions necessary for liquefaction to occur are rather specialized and require basically sandy materials to be saturated with water within 40 to 50 feet of the surface. If the

groundwater is within 15 feet of the surface, it could actually affect single family dwellings under intense ground shaking from a very large earthquake. If the liquefaction is between 20 and 40 feet of the surface, it would only affect very large or high rise structures with deep foundations.

At the present time, the only area of potential liquefaction occurs east of Virginia Colony, along the channel of the Arroyo Simi where high groundwater tables have been experienced in the past. However, the groundwater table levels within the City itself north of the Arroyo Simi, have been rising rapidly over the last few years and are projected to be within 15 feet of the surface within the next 10 to 20 years if not mitigated. This hazard affects structures when all of the conditions occur at the same time. In summary, these conditions are:

1. There must be sandy, fairly cohesionless soils under the site.

2. The groundwater level must be within the foundation range of the structure.

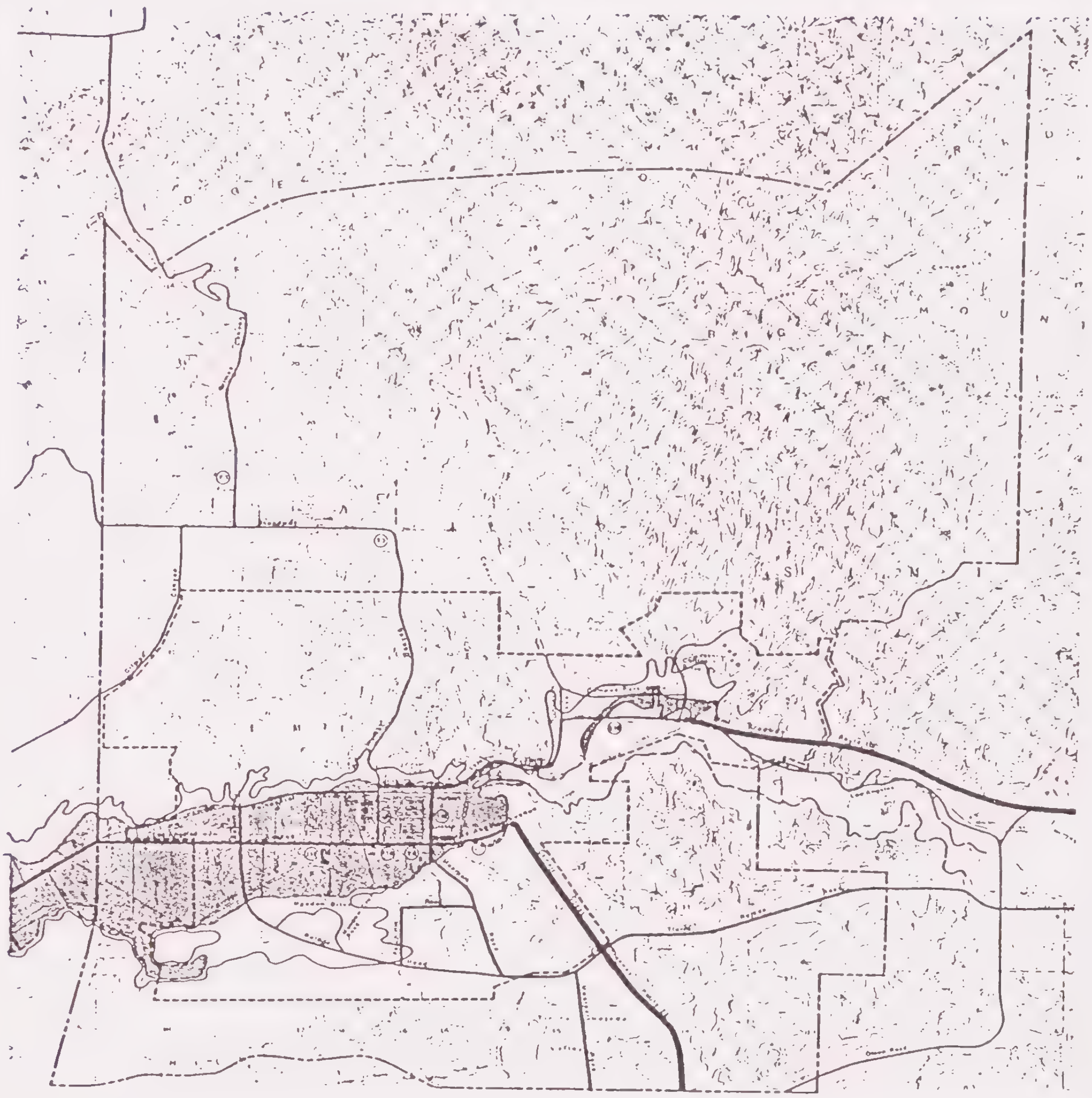
3. There must be intensive ground shaking over a fairly continuous period of time.

Only under extreme circumstances do these conditions occur at the same time. The areas that potentially could be affected by liquefaction are indicated on Moorpark Safety Plate II.

No developable area within the City is presently affected by the liquefaction hazard. At some time in the future, liquefaction may become a threat to certain structures under the very restricted circumstances in which liquefaction can occur. Those areas would be faily limited and occur along the Arroyo Simi in the basically flat areas of the City.

POLICY

The City should continue to monitor ground water levels in all potential Liquefaction areas. If the water levels reach within 40 feet of the surface, the City Engineer shall require appropriate foundation design or other mitigations to alleviate the hazard to large structures as necessary. If the water levels reach within 15 feet of the surface the City Engineer shall require special designs for other structures as necessary.



LEGEND

Existing Water Table Level Within 15' of Surface

Projected Level Within 15' of Surface

Water Table Level Within 40' of Surface

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE II

Liquefaction

CITY OF MOORPARK

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LANDSLIDE/MUDSLIDE

All hills, mountains and other highlands are being worn down by various natural processes. The most spectacular of these is the landslide, along with other related types of ground failure. There are a number of different causes for the various types of landslides that occur. These causes include stream erosion which can undercut slopes, thereby, removing support and causing failure of slopes by landsliding and saturation of soil or bedrock on hillsides that can reduce the strength of these materials under certain conditions to a point where downhill sliding can occur in response to gravity.

Rainfall can also saturate and erode vast quantities of loose soils, especially after large fires denude slopes, washing it downhill as earth or mud flows. Earthquakes can directly shake loose materials to fall or slide downhill; it can also cause liquefaction of subsurface materials which can also lead to slides.

Finally, manmade cuts or excavations can undercut unstable slopes, thus causing landslides. In practice, most landslides are caused by a combination of two or more of these factors.

The speed with which landslides can occur very considerably from rapid rockfalls to virtually inperceptible movements down slope under the pull of gravity. Soil creep is a very slow type of earth flow movement. It occurs mainly in soils containing clay. Most landslides are shallow, ranging up to perhaps 100 feet in depth and limited in extent to generally less than 100 acres. Most are not presently in motion (active), but have moved down slope to a position of stability and there have remained.

Generally, stability is achieved within several years after the initial failure under natural conditions. However, the margin of stability of most landslides is small and inadequate to safely place structures on their surfaces. Many of the existing landslides can be reactivated and down slope movement renewed after an exceptionally heavy rainfall period or as a result of earthquake shaking. Most landslides are over 100 years old and can exist for thousands of years until all of the landslide material is removed from the hillside by erosion.

There are basically two areas within the City of Moorpark which have a higher than normal landslide hazard. One of these is north of Tierra Rejada Boulevard in the hillside area between the Tierra Rejada and the Arroyo Simi east of the Moorpark Freeway (Highway 23). The other area is located between Grimes and Walnut Canyons, south of Broadway and north of the regular Moorpark valley area. Both of these areas contain a number of existing landslides and have a potential for other landslides if improper excavation or changes in soil conditions occur.

LEGEND

Existing Landslide Area

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE III

Landslide

CITY OF MOORPARK

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FLOODING

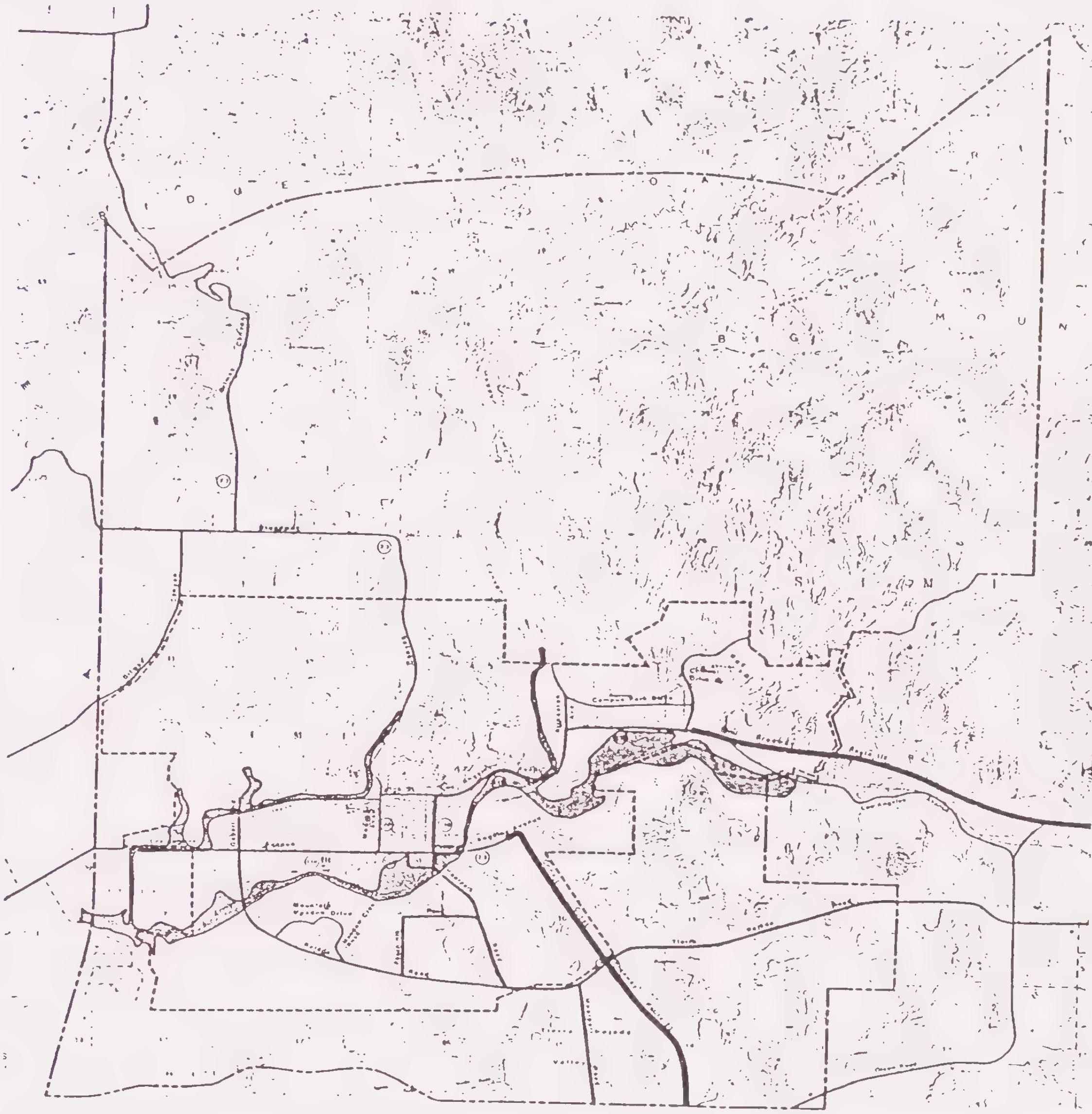
A flood may be defined as a "temporary rise in stream flow or stage that results in water over topping its banks and inundating areas adjacent to the channel". The area subject to inundation is generally referred to as the flood plain. The size and frequency of occurrence of a flood in a particular channel depends upon a complex combination of conditions, including the amount, intensity and distribution of rainfall, previous moisture conditions and drainage patterns. The magnitude of a flood is measured in terms of its peak discharge which is the maximum volume of water passing a point along a channel.

However, floods are usually referred to in terms of their frequency of occurrence which is related to discharge. For example, the 100 year flood for a particular channel is the size flood which has a probability of being equaled or exceeded once in each 100 years. Flooding is a natural occurrence, with some long range beneficial aspects such as replenishment of sand to beaches and of nutrients to agricultural lands. It is a hazard only because people find flood plains a desirable place to live and to use. Man's encroachment on flood plains can also increase the hazard. Structures may obstruct the flood flow, thus increasing flood heights and the covering of the ground with impervious surfaces (e.g., pavement) increases the rate and

quantity of runoff. Damaging floods have occurred throughout the history of Ventura County and Moorpark, with the most significant floods along the Calleguas Creek drainage, which includes the Arroyo Simi, in 1980 and 1983. The hazard within the City of Moorpark is determined under the Policies of the National Flood Insurance Act and is delineated in the FIRM (Flood Insurance Rate Maps) as prepared by Federal Emergency Management Agency for the National Flood Insurance Program. These are delineated on Moorpark Safety Plate IV. The flooding areas that are affected by the 100 year flood include areas along the Arroyo Simi and Happy Camp, Walnut and Balcom Canyons. Those areas presently impacted or potentially impacted by flood are covered by the National Flood Insurance Act which is required for loans for structures built in the flood plain areas.

POLICY

The best way to minimize the impacts of flooding is to impose land use restraints upon any development within the flood plain or to minimize the hazard by improving the channel to carry the 100 year flood. Both of these are being addressed as methods of alleviating the hazard within the City of Moorpark and have resulted in a significant reduction in the flood hazard in the last few years and they will be continued.



Area Of 100 Year Flooding

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE IV

Flood Hazard

CITY OF MOORPARK

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DAM INUNDATION

The failure of a major dam can cause a flood of a magnitude much larger than any natural flood that can occur within that watershed, depending upon the size of the dam and the amount of water being impounded. In recognition of this potential hazard, the State of California, for many years, has required all dam operators to prepare inundation maps should their dam fail catastrophically. Dam inundations have twice impacted Ventura County. The first time was in 1928 with the failure of the St. Francis Dam, part of the Los Angeles Aqueduct system which flooded the Santa Clara River Valley from Saugus to the sea between Oxnard and Ventura. This dam inundation caused extensive loss of life and much property destruction. The second dam failure was of the Sinaloa Dam in Simi Valley. That affected the Arroyo Simi drainage, but all of the water was successfully removed from the dam and flooding was restricted to the immediate channel bottom downstream from the dam and presented no significant hazard to either life or property. Modern dams within the State of California must meet stringent design and construction standards and are regularly inspected by the State of California for their safety.

None of the existing dams within the County have shown any increased degree of hazard and the potential for dam failure of

any of the major dams is considered extremely slight. The only dam that affects the City of Moorpark would be the Lake Bard Dam located upstream of Wood Ranch within the Arroyo Simi. This modern earth filled dam is operated by the Calleguas Municipal Water District and is the western most terminus of the Metropolitan Water System and serves Thousand Oaks, Simi Valley and Moorpark with domestic water. This dam was built to the highest engineering standards, is regularly inspected and poses virtually no threat to the City of Moorpark.

POLICY

Dam inundation maps have been prepared by the dam operator and are maintained at the City and the County for any potential emergency management purposes. No further action is necessary.

FIRE HAZARD

Ventura County and the City of Moorpark are located within the Southern California area that has a climate generally referred to as "Mediterranean" with the rainfall concentrated in the most efficient months, during the cool winter when there is less evaporation. The rainy winters are caused by the dominance of the cool moist north Pacific weather which is characterized by the frequent passages of storm fronts, followed by clear and temperate periods. These winter rains are stored in the ground and in the vegetation to assist it over the summer drought. The rains usually stop some time in May and there is a drought often lasting into November. This summer drought is the dominant characteristic of this climate. It is caused by the tropical desert air patterns that are dominant during this time period. Actually, this simplified model is not entirely correct, since the alternation of the seasonal patterns is rarely exact and in consequence, there is a high variability in rainfall and dominant weather patterns.

The natural Southern California vegetation has adapted to the summer drought cycle. The annual plants, grass and wild flowers mainly pass through the active phases of their lifecycles in early spring, go to seed and die in early summer. When they die, they turn the hills golden and brown, the dry grass substantially

increased the fire hazard. The perenial plants also have special adaptations to resist the drought. Most are naturally desert plants, such as sage, that dominates in the Coastal Sage Vegetation Association which is common within the Moorpark City limit area. The special adaptations of these plants include slow growth, small leaves and the ability to both shed a portion of their leaves during the summer drought and develop waxy coatings on their leaves to cut down evapotranspiration. Unfortunately, these latter two adaptations are major contributors to the extreme flammability of the Chaparral and Coastal Sage Vegetation Associations as they increase the amount of fuel available to a fire and the waxy coating are extremely flammable. Fire is a normal part of the lifecycle of these associations and is periodically necessary to maintain healthy plant and animal communities.

The problem occurs when man's improvements are built in close proximity to these highly flammable plants. The best way to protect the human resources is to remove the possible interaction by locating improvements outside of the natural vegetation areas or regularly removing the vegetation. County and City Fire regulations require clearance if at least 100 feet from any structure and the fire department recommends a much larger clearance. The City has required fire resistent roofs for all new construction.

All of the hillside areas surrounding the City are affected by the hazard and it can extend into any part of the City when the natural vegetation is not removed at least annually.

POLICY

The fire department will continue to vigorously enforce the fire clearance regulations which significantly reduces the fire hazard to structures. All new construction shall have noncombustible roofing material consistent with Uniform Building Code requirements and shall exclude wood-shakes.

EXPANSIVE SOILS

Expansive soils (which are identical to soils referred to elsewhere as having a shrink-swell potential) are those which are generally clayey, expand or swell when wetted and contract or shrink when dried. Wetting can occur naturally in a number of ways, i.e., rain, absorbtion of water from the air, groundwater fluctuations, as well as from other sources, i.e., lawn watering, broken water or sewer lines and septic tank leach fields.

In the 1960's, epansive soils caused severe damage to many housing developments. While significant construction deficiencies were noted, more conservative engineering design provisions and regulations were initiated which effectively eliminated the hazard to later construction. Subsequent engineering studies have resulted in tests and design procedures which provide safe and economical designs for expansive soils. Local building ordinances have incorporated these concepts in recent years.

The only area relating to expansive soils which must continue to receive special attention, is downslope soil creep in hillside areas. As an expansive soil expands and contracts, it tends to move downslope in response to gravity. Recognition of this condition by all parties should not be overlooked. This condition may require flatter slopes, soil removal and special landscaping and irrigation treatment.

The tremendous force exerted by the expansion of soils is generally not understood by the average person and quite often results in requests for waiver of the soil test as "unnecessary". Such a complacent attitude is unjustified. In no way should the ability to provide designs for expansive soils give one the feeling that expansive soils are no longer a factor to be considered.

The U.S. Department of Interior, a Soil Conservation Service has prepared a soil survey of the County and shrink-swell or expansive soils were among the factors evaluated.

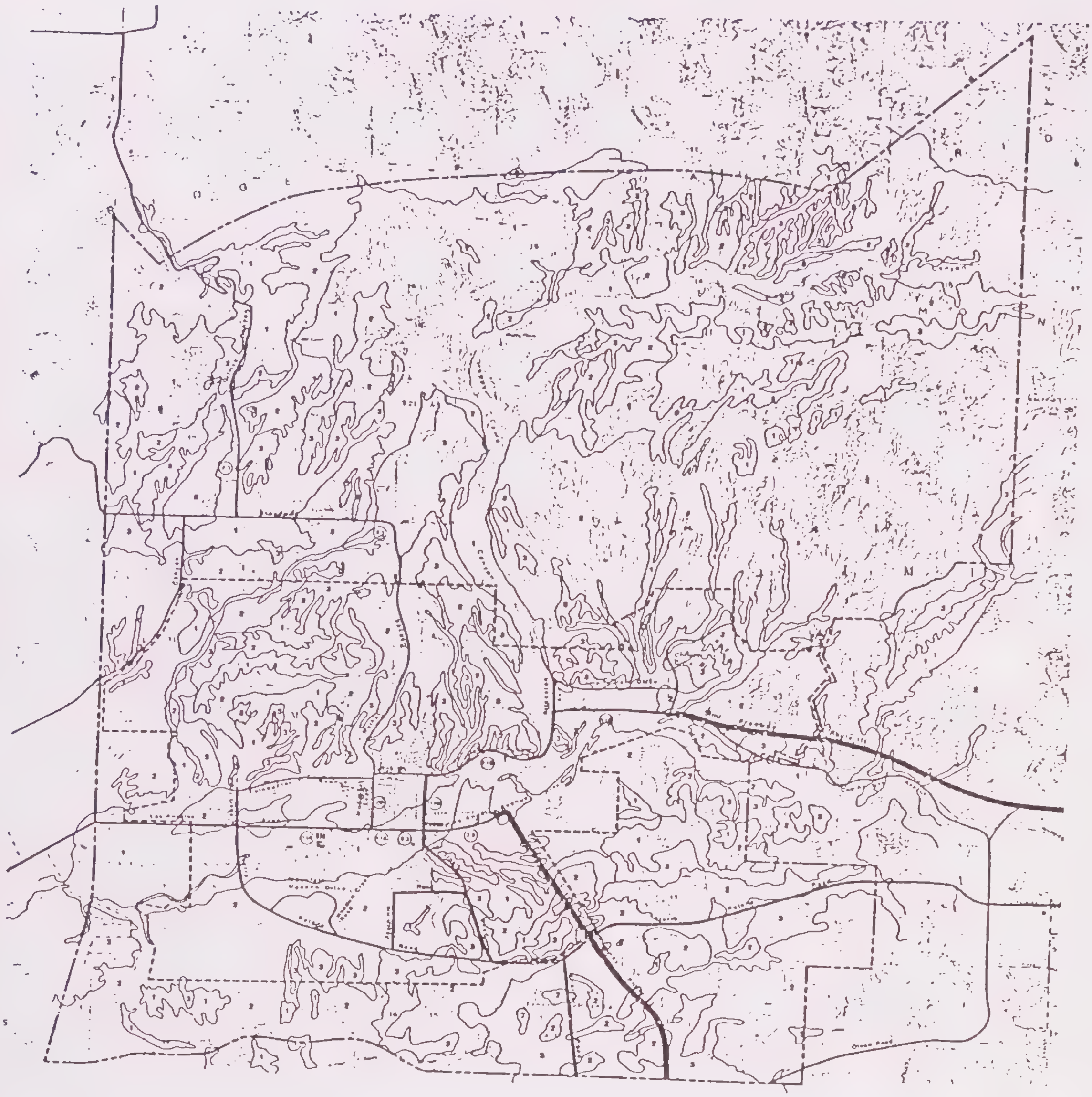
There are a number of areas of the City and its surroundings that have a high shrink-swell potential in the soil. The resources most often affected by this hazard are structures. The presence of expansive soils presents no threat to a properly designed and constructed building, because soil tests and proper engineering can completely overcome the danger. However, hillside areas of expansive soils should be studied for possible extra treatment such as special landscaping or retainng walls. The hazard areas are indicated on Moorpark Safety Plate V.

Fully 20% of this nation's land area will be affected by expansive soil movements during the period of the average person's lifetime. Typically, expansive soils are located in areas generally most attractive for intense, urban type uses. The movement of expansive soil may be slow, progressing over a

period of years. Commonly, this movement is associated with seasonal or even longer wet/dry cycles.

POLICY

No further action is necessary. This hazard is successfully mitigated in structures by proper foundation design as required by the City Engineer and the Building and Safety Department. Homeowners building patios, decks or other structures should get expert advice on design and construction when building in areas with soils having a moderate to high shrink-swell potential.



LEGEND

- High Shrink-Swell Potential
- Moderate Shrink-Swell Potential
- Low Shrink-Swell Potential

LEGEND

- AREA OF INTEREST
- CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE V

Expansive Soil

CITY OF MOORPARK

JSA Joel Silverman & Associates

North 0 2000 4000 FEET

SAFETY ELEMENT

VOLUME II

Safety Element

CITY OF MOORPARK

JSA

CITY OF MOORPARK

Safety Element
of the General Plan

Prepared by

Joel Silverman & Associates
for the City of Moorpark

Including Portions of the Seismic Safety
and Safety Elements Prepared by the
County of Ventura, October, 1974.

July, 1986

ACKNOWLEDGMENTS

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INTRODUCTION

"Where have all the houses gone . . .

Once upon a time people mostly lived in the country and every day as they worked and played they learned about rocks and water. They learned that rocks and water run downhill. So when they built their houses they built them away from running rocks and running water. Today people mostly live in cities and they know about running automobiles and running stores, but they don't know about rocks and water. People build cities almost anywhere: in the desert, in the low valleys and the high mountains, and by the seashore.

Some people like to build their houses in the desert because the desert is dry and the hills are rocky, bold, and clean. But rocky hills are hard, and hard to build on, so the people build their houses in the narrow canyons between the hills. These people don't know why the hills are bold and clean. They are bold and clean because in the dry desert, floods wash away the rock and soil. Then, the rock and soil and water flush down the narrow canyons and through the houses the people build.

Some people like to build their houses in a long straight valley. They don't know why the valley is long and straight. The valley is long and straight because it follows an earthquake fault. Sometimes the fault makes the valley quake, and this shakes the people up while it shakes their houses down.

Some people like to build their houses among the big green trees in the mountains. These people don't know why the trees are big and green. They are big and green because big green trees like lots of rain. The rain that they like sometimes knocks them down then picks them up; rain also picks up rock and soil. Then the rain and trees and rock and soil go bouncing down the canyons and through the houses that the people build.

Some people love the sea so they build their houses on seacliffs. Those who love the sea the most build their houses at the edge. These people don't know why the seacliffs are there because they spend their time looking at the sea and not the cliffs. The seacliffs are there because the land is in the way of where the sea wants to go and that is why they are called seacliffs. The cliff houses are on the land that's in the way of where the sea wants to go, so the cliff houses go too, see?

Some people like to build their houses on soft rocks because soft rocks are easy to build on. But soft rocks can't stand people building on them, so they don't. Soft rocks are sometimes found on little shelves along a hillside or the bumpy ground below. Little shelves and bumps on hillsides are called landslides. Most landslides are on their way somewhere, and houses built on landslides that are on their way somewhere are on their way somewhere. ☆

. . . gone to kindling every one"

George B. Cleveland

California Geology
May 1973

(INTRODUCTION TO MOORPARK SAFETY ELEMENT - MAY, 1986)

The Moorpark Safety Element was envisioned to be merely an update of the 1974 Ventura County Seismic Safety and Safety Elements with inclusion of more detailed data for the City of Moorpark. During the research and writing of the Element, a number of new factors were discovered which required a more extensive update, both of portions of the County Element and a more detailed analysis of the City area itself.

The basic County data that was compiled in the general sections under the various hazards in the 1974 Safety Element is, by and large, excellent, descriptive material and accurately reflects the conditions that exist in Ventura County. This information gives good background data for evaluation and discussion of the various hazards that affect the City of Moorpark and as such, has been included to provide the necessary supplement to the more detailed analysis of the City hazards themselves.

New information was necessary to update certain sections of the County text. This new data was originally generated in a number of ways. One of the first were Seismic Hazard Studies that are part of an ongoing effort to upgrade the comprehensive view of hazards in the southern and selected northern portions of Ventura County. These studies were started by a cooperative hazard study

instituted between the County and the State Division of Mines and Geology in 1974. The result was a Seismic Hazards Study of Ventura County and in 1975, an open file report 76-5-LA was prepared by the California Division of Mines and Geology in cooperation with the County of Ventura. A number of factors were evaluated and new data generated by that report and the results of that report have been included within the Moorpark Safety Element.

An ongoing process by the State of California has been to evaluate each of the possibly significant faults in the State, to determine whether or not those should be included within the Alquist-Priolo Seismic Hazard Zones which are designated along each of the active faults within the State of California. A number of faults and fault segments have been evaluated in the County over the last twelve (12) years and the results of those evaluations have also been included in the City Element.

As part of the general review of the background information and discussions with the County staff, the author determined that the groundwater conditions had changed fairly radically within the City over the last ten (10) years. That information was further researched, including some primary research on watertable levels. These new water levels were mapped and that information is also included within the relevant sections.

Another area that was done basically from scratch for the

Moorpark Safety Element was the local discussions of the hazards under each of the hazard sections. These were prepared for the County of Ventura and each of the then nine (9) cities in 1974 and new discussions have now been prepared for each of the relevant hazards in the City of Moorpark.

The County Element contained a number of sections which have no bearing on the City and those sections were deleted from the Moorpark Safety Element. The remainder of the County Elements were retained and updated as necessary.

Fault Displacement Hazard -- This section includes new data on the Simi-Santa Rosa Fault and its potential activity.

Groundshaking Hazard -- A local discussion was prepared, but no futher mapping was deemed necessary as no more detailed data was available.

Liquefaction Hazard -- The new and changing groundwater data required a complete reevaluation of this hazard and new primary mapping for the Moorpark area. The results included a potentially threatening increase in groundwater levels in the near future within the City which could increase this hazard noticeably.

Flooding -- Channel improvements and more detailed analysis by the County and Federal governments have concluded that the

Flooding Hazard, that is, the 100 year flood plains within the City, have actually been reduced in area and new maps have been prepared. A new description has been included within the Element.

Landslide/Mudslide Hazard areas have been identified for particular areas in the City and new maps have been prepared. Also, detailed hazard areas within the City have been identified.

Expansive Soils -- Although this hazard is mitigatable during construction; for comparison purposes and for use by the City staff, a detailed hazard plate has been prepared for expansive soils covering the entire area of interest of the City.

Dam Inundation -- The Dam Inundation Hazard was not included within the 1974 Safety Element for the County, since three of the key dams affecting the County area had not prepared Dam Inundation maps at the time that Element was published. The County has not subsequently updated their Element to include this section which is required by State Planning and Zoning Law. A new section has been prepared for this Element which is both a general discussion of the hazard throughout the County and the more detailed discussions of the hazard in Moorpark. However, a map was not prepared, due to the sensitivity of the data.

Fire -- Fire basically affects the hillside areas that retain natural vegetation throughout the City. A local discussion was

prepared. However, no further mapping was deemed necessary.

It is the hope of the author that the Element will be useful to the City, both for illustrative purposes and as an ongoing reference data base for evaluating projects and potential land uses. The maps have been prepared, both at a reduced scale for inclusion within the Element and at the base 2,000 scales, the same sale the other City General Plan Elements have been prepared at and will be available as a resource for the City as needed.

County Seismic Safety and Safety Elements - 1974

BACKGROUND

In 1971, the California Legislature passed legislation requiring two new elements to be added to the General Plans of all cities and counties in the State. These were the Safety Element and the Seismic Safety Element.

The impetus for this legislation was a series of natural disasters which had occurred in Southern California in the preceding 2 years. The winter of 1969 saw particularly heavy rains, especially during January and February. Serious flooding occurred in many areas of Southern California but especially in Ventura County. These heavy rains caused substantially increased growth in the Chaparral vegetation belts of the Southern California hills and mountains. Then during thirteen days of September and October, 1970, a series of disastrous fires broke out, fanned by dry desert Santa Ana Winds. The fires burned over half a million acres of brush and timber land, destroyed 722 homes, killed 16 people and cost $233 million to control. The following winter landslides and mudslides occurred in the hills and damaged many of the structures that had escaped the Fall fires.

In response to these disastrous floods, fires and landslides, the 1971 Legislature enacted Government Code Section 65302.1, which requires of each city and county general plan:

> *A safety element for the protection of the community from fires and geologic hazards including features necessary for such protection as evacuation routes, peak load water supply requirements, minimum road widths, clearances around structures, and geologic hazards mapping in areas of known geologic hazard.*

The impetus for the Seismic Safety Element was the February 9, 1971, San Fernando Valley earthquake. This earthquake of 6.6 magnitude took 65 lives and caused almost $1 billion of damage to freeway interchanges, hospitals (accounting for the greatest loss of life), utilities, dams, and public, private, commercial and industrial buildings. The earthquake also pointed up major discrepencies in building design and a laxness in land use planning.

This disaster prompted the Legislature to require another element to the general plan, a Seismic Safety Element. Government Code Section 65302 (F) requires:

> *A seismic safety element consisting of an identification and appraisal of seismic*

hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failure or to the effects of seismically induced waves such as tsunamis and seiches. The seismic safety element shall also include an appraisal of mud-slides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

Both elements are required to be adopted by September 20, 1974; however, time extensions may be granted under special circumstances. While there was no penalty attached to the original September 20th due date, State authorities have hinted that citizens may be able to bring class action suits against the jurisdictions not complying with the deadlines. Specific penalties may be created if the mandated adoption date is extended by the Legislature; such was the case when the deadline for the Open Space Element was extended.

The preparation of the Seismic Safety and Safety Elements (hereafter referred to as the Seismic and Safety Element) is a coordinated effort between the County of Ventura and the nine cities within the county. It was felt that since most of the hazards are regional rather than local in scope, that a general countywide treatment of each hazard would be more valuable than ten separate, locally oriented elements. The element, then, represents the culmination of participation either directly or indirectly by all cities within Ventura County.

PURPOSE

In preparing the Seismic Safety and Safety Elements, a number of purposes will hopefully be achieved. Among these are:

1. To meet the requirements of State law.
2. To integrate the Seismic Safety and Safety Elements into one coherent document.
3. To investigate the various hazards from a regional as well as a local perspective so as to provide a more integrated picture of the hazardous conditions within Ventura County.

4. To develop a framework which will permit the investigation of all types of hazards and the resources they impact.

5. To present the information collected in a form which will allow decision makers and the public to quickly evaluate the pertinent aspects of a given hazard.

6. To offer a range of response measures from which decision makers may choose as they attempt to alleviate a given hazard.

7. To provide a framework in which future inventory and analysis can be performed.

ORGANIZATION

INTEGRATED ELEMENTS

Because of the confused and overlapping nature of the mandated Seismic Safety and Safety Elements, it was decided to merge the two into one integrated discussion of hazards. This procedure was also recommended by the State General Plan Guidelines.

REGIONAL EMPHASIS

In discussing hazards which affect both incorporated and unincorporated portions of Ventura County, it was necessary to conduct a comprehensive regional study while also providing detailed treatment of local areas and problems. To this end, each hazard is discussed from a regional standpoint prior to being examined at the local level.

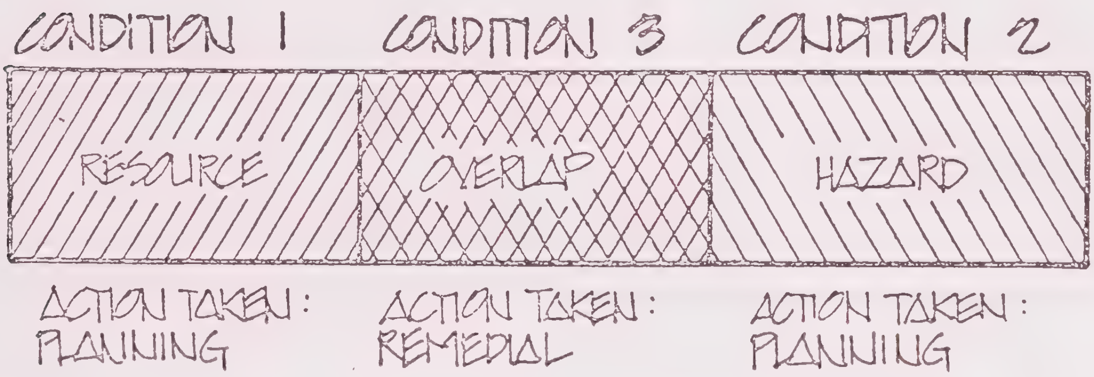
The result of this approach to the two elements, is that each entity will receive one document whose general discussion of the various hazards will be the same as that received by the other entities. Each entity, however, will receive its own individualized discussion of the hazard within its jurisdiction.

ANALYSIS FRAMEWORK

Before embarking on the preparation of the two hazard related elements it was necessary to devise a framework for analysis that would allow the integration of the two elements into one document and permit the systematic investigation of hazards not set out in State law.

The framework decided upon, views hazardous conditions as an interrelationship between resources (natural, human, and man-made) and hazards (natural and man-made). Hazards and resources often exist apart from one another and under such conditions, it is generally concluded that a problem does not exist. For example, landslides in the north half of the county or on Sulphur Mountain are not thought of as hazards because they generally do not affect people or property. Landslides in the Camarillo Hills or immediately above the City of Ventura, however, are usually considered hazardous because they may impact people and property.

The analytic framework, then, identifies three types of conditions: one in which a hazard exists apart from resources; one in which a resource exists apart from hazards; and one in which hazards and resources exist in proximity to one another. In the first two cases, there is an opportunity to plan around the resource or hazard - to prevent hazards from encroaching on resources or to locate resources away from hazards. In the third case where there is an overlap of resources and hazards, planning may not be as effective as various remedial measures.



The Seismic-Safety document has been developed along the lines of this framework in that it identifies resources and hazards, and the instances where they overlap. The hazards are mapped on 1" = 4000' scale maps for the county, 1" = 1000' for the cities and on 11" x 17" sheets contained within the document. Resources will be plotted on transparent sheets which can overlay the 11" x 17" hazard maps.

HAZARD EVALUATION

One of the purposes of the Seismic and Safety Elements is to provide decision makers with the information necessary to evaluate the nature of a given hazard and possible courses

of action. To facilitate this, it is felt that decision makers and the general public should have a general knowledge of a hazard, know where it exists and who is managing it.

In addition, one should know the probability of the hazard occurring, the severity of the hazard should it occur, the resources that are apt to be affected, and the validity of the information which leads to conclusions in the above areas. This information is summarized in the FINDINGS Section of each hazard and should be evaluated and used as a basis for responding to various hazards.

One aspect not addressed in the document, but which will automatically enter into any final decision relative to hazards, is the cost involved. This matter was not addressed because only the local jurisdiction can place values (benefits) on resources that may be lost; and only the local jurisdiction can decide on the appropriate response to a hazard and its attendant costs. A local entity's conclusions about costs and benefits are then the final elements in a Risk Analysis which evaluates: probability, severity, resources, the validity of information, and cost-benefits.

This document, then, attempts to present the available information necessary for a response to a hazardous condition. It does not attempt to make the types of value judgements that ultimately rest with local decision makers.

In addition to the written text, there are a number of maps that accompany each hazard discussed. These maps are an essential part of any hazard evaluation. Hazard zones appear on these maps which depict varying degrees of severity for a given hazard. While these zones are, by necessity, defined by distinct lines, the hazard depicted may not conform exactly to the defined zones. The reasons for this are imprecise data, and small scale maps which do not permit the detailed plotting of data.

For these reasons, the zones that are defined should not be used for specific planning purposes, but rather, should be used to direct more precise studies which would specifically delineate the location and nature of the hazard in question. The various hazard zones, then, define areas of probable hazard which should undergo further study. Additional studies, for example, might be done to allow for more precise planning, or to determine the conditions at a specific construction site.

OPTIONS

After evaluating the information presented on a given hazard and in particular the FINDINGS, an entity must decide on an appropriate response. Responses may range from doing nothing

at all to enacting new ordinances. As the assessment of a hazard must ultimately be made by the local jurisdiction, so must the jurisdiction decide what type of response is warranted by its assessment. To assist in this matter, this document offers a range of responses for each hazard from which the jurisdiction may select what it feels are appropriate responses. These prospective responses are termed "options."

The options that are found with each hazard represent a range of implementation measures or concepts from which formal recommendations can be drawn. Before adopting any options, they should be carefully evaluated and coordinated with the agencies and interests, both public and private, which may be affected. They are not intended to be recommendations, but rather a series of alternatives which individually or collectively can be employed to correct a situation or condition identified in the FINDINGS section, which preceded the OPTION section of each hazard.

The range of options is designed to be a pool from which final recommendations can be drawn and proposed by the appropriate staffs to their respective planning commissions, city councils, or Board of Supervisors. The county planning staff then, will not be making recommendations but will offer a range of alternative responses for each hazard from which the staffs from the respective entities may develop recommendations.

This approach was selected because recommendations should come only after a hazard has been assessed in light of local interests and concerns. It was felt that the staffs and citizens of the respective jurisdictions, being in touch with local attitudes, could make more appropriate recommendations than could the county planners preparing the element.

In addition to the specific options offered with each hazard, there is an Options Matrix in the appendix to the Seismic and Safety Elements document which is designed to offer additional response alternatives. A discussion of the Matrix and how to use it can be found in the appendix.

RECOMMENDATIONS ON OPTIONS

To assist the various staffs and decision makers in selecting the appropriate responses to conditions identified in this element, the recommendations of various authorities and advisory groups have been included in the rear of the document. The adoption of these recommendations is not required; they are only intended to guide in the selection of appropriate responses.

ACCEPTABLE RISK

Implicit in the State law mandating a Safety Element, and explicit in the General Plan Guidelines published by the

FAULT DISPLACEMENT

Safety Element
CITY OF MOORPARK

JSA

State, is the notion of "acceptable risk" - "The level of risk below which no specific action by local government is deemed to be necessary."

This issue is addressed by an entity when it performs a Risk Analysis of a given hazard and subsequently decides on an appropriate response. The response that is decided upon implicitly identifies the level of risk that was perceived. If the response is "no action," then it may be concluded that the level of risk is acceptable and perhaps quite low. If on the otherhand, a strong response is issued (such as the immediate abatement of certain structures), then it might be concluded that the level of risk is unacceptable and possibly quite high.

ADDITIONAL INFORMATION

In early 1974 the County of Ventura entered into an agreement with the State Division of Mines and Geology for the preparation of a Geologic Hazards investigation of Ventura County. This 50/50 matching study of $50,000 will provide additional information relative to the geologic hazards discussed in the Seismic and Safety Elements, upon its completion in June of 1975.

Civilization exists by geological consent,
subject to change without notice.

Will Durant
What is Civilization?

GENERAL DISCUSSION

GENERAL DESCRIPTION

Surface Faulting (D. R. Nichols, U.S. Geological Survey)

The earth is laced with faults - planes or surfaces in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress. Most of these faults have not moved for hundreds of thousands or even millions of years and thus can be considered inactive. Others, however, show evidence of current activity or have moved sufficiently recently to be considered active, i.e., capable of displacement in the near future. Any fault movement beneath a building in excess of an inch or two could have catastrophic effects on the structure, depending upon its design and construction, and the shaking stresses it experiences at the same time. Therefore, it is important to know not only which faults may move but how they might move.

The definition of what constitutes an "active fault" may vary greatly according to the type of land use contemplated or to the importance of the structure. For example, the Atomic Energy Commission regards a fault as active or "capable" with respect to nuclear reactor sites if it has moved "at or near the ground surface at least once in the past 35,000 years;" or "more than once in the past 500,000 years" (Atomic Energy Commission, 1971). Commonly, faults are regarded as active and of concern to land-use planning when there is evidence that they have moved during historic time,or, through geologic evidence there may be a significant likelihood that they will move during the projected use of a particular structure or piece of land. Because geologic evidence may be lacking, obscure, or ambiguous as to specific times of past movement, geologists may be able to estimate relative degree of activity only after a regional analysis that may extend far beyond the locality under consideration. Such analysis may be based on historic evidence of fault movement, seismic activity (occurrence of small to moderate earthquakes along the fault trace even though not accompanied by obvious fault movement), displacement of recent earth layers (those deposited during the past 10,000 years), and presence of topographically young fault-produced features (scraps, sag ponds, offset stream courses and disruption of man-made features such as fences, curbs, et.) Movement, however, seldom is limited to a single fault surface throughout the lifetime of a fault system. Faults that commonly produce significant displacement (more than several inches at a time) often have related branches that diverge from the main fault but usually have less movement along them. They may also have secondary faults that are not directly or obviously connected physically to the main

fault trace. Secondary faults are usually nearby (within hundreds of feet of the main rupture) but they may extend as much as several miles away. As with branch faults, displacement along secondary faults is usually only a fraction of that along a main fault.

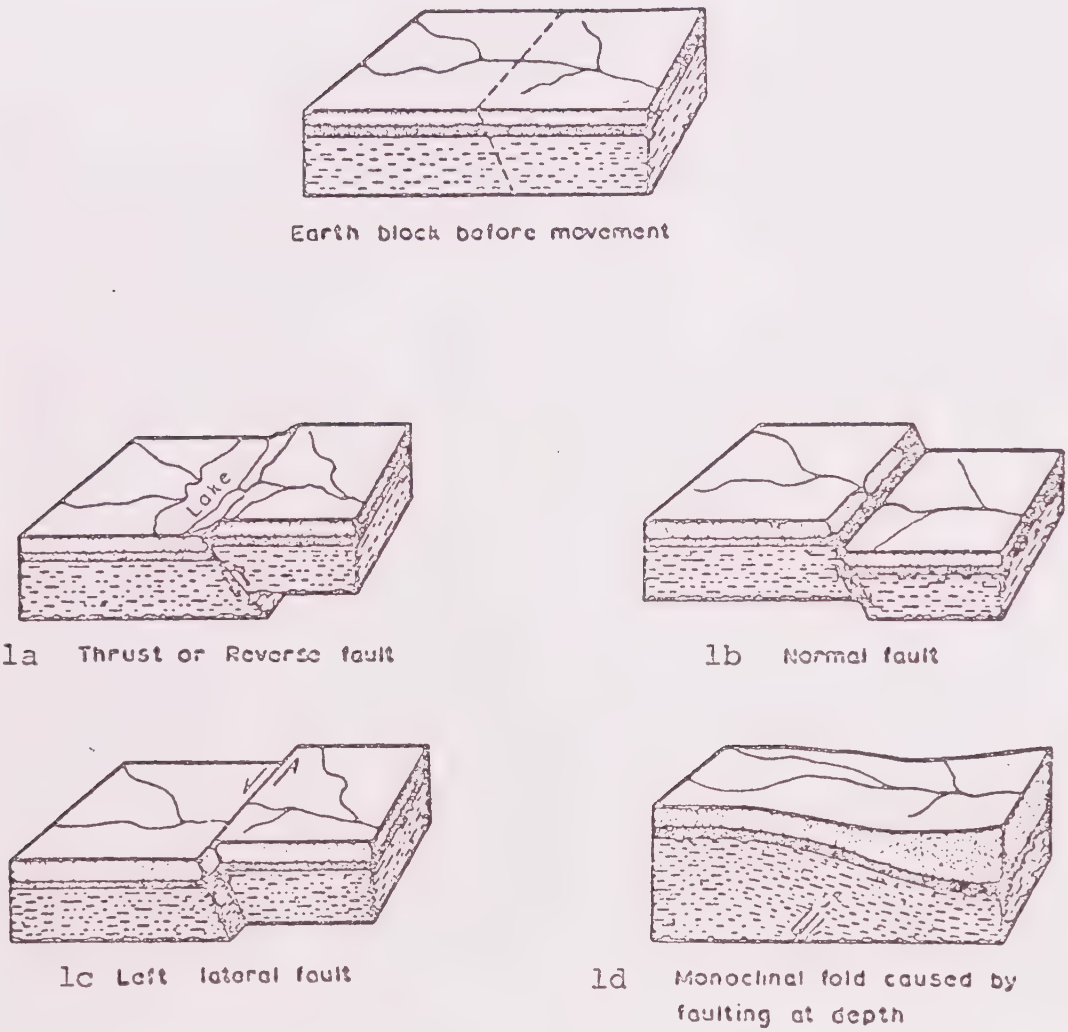
The amount of displacement that can occur during a single earthquake can be related in a general way to the total length of a fault. However, in addition to the location and amount of displacement, the sense of movement is extremely important in estimating the amount and type of damage that might be produced. This was evidenced by the great damage over faults during the moderate (magnitude 6.6) San Fernando Earthquake, which produced a reverse or thrust fault movement. (See Figure 1a). Movement occurred along a similar plane, but in an opposite direction on the normal Wasatch Fault in Utah. (See Figure 1b). Left-lateral movement (Figure 1c) and right-lateral movement, which is common to the San Andreas Fault, probably are less potentially damaging to most structures than normal or thrust faulting.

Not all surface faulting need be rapid nor need it occur during major earthquakes. Imperceptibly slow movement, called "fault creep," occurs along the Hayward, Calaveras, and some other faults, and may be accompanied by microearthquakes. Similarly, not all deformation of the earth's surface produces fault displacements. Strains in the earth deform the rocks until their strength is exceeded and they rupture, producing the earthquake. Accompanying this bending, however, is a certain amount of plastic deformation. Both rupture and plastic deformation commonly occur along active fault zones and may be sufficient to damage or destroy structures over particularly strongly deformed rocks. Earthquakes deep within the earth may result from rupture of deeply buried rocks but without fault displacement at the ground surface, although the surface rocks may be deformed (see Figure 1d). This may have been the case along a part of the Newport-Inglewood Fault zone where movement along the fault during the last 10,000 years or so has merely caused a permanent flexuring or bending of the surface rocks.

For planning purposes there are two kinds of faults: (1) active faults which have experienced displacement in recent geologic time, suggesting that future displacement can be expected on these faults; and (2) inactive faults that have shown no evidence of movement in recent geologic time, suggesting that these faults are dormant. However, some faults labeled as inactive are so termed due to lack of knowledge. Increased research and monitoring of these faults could reveal some of them as active.

The State Division of Mines and Geology ("Urban Beology," 1973, Bull. 199) indicates that on a state-wide basis the potential hazard to strucutres from the surface displacement of faults

ILLUSTRATION 1 EXAMPLES OF SOME TYPES OF FAULT DISPLACEMENT AND EARTH FLEXURE



Source: <u>Tri-Counties Seismic Safety Study</u>, 1973, pg. 68.

is low compared to such geologic phenomena as earthquake shaking and landsliding. Historically, major losses due to fault displacement have been limited to the San Fernando Earthquake of 1971. Structural losses due to fault displacement in the 26 other major earthquakes in California are unknown but were probably small. Most of the losses incurred during the 1906 San Francisco Earthquake and 1952 Tehachapi Earthquake were caused by earthquake shaking and ensuing fires.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

Nearly all man-made structures are susceptible to damage ranging from severe to total when affected by displacement along faults passing beneath their foundations. The San Fernando Earthquake of 1971 has shown that no structures designed under present standards are safe from severe damage or destruction as a result of surface fault displacement of foundations. It is widely acknowledged that design of most structures, such as single family homes or larger structures, roads, bridges, pipelines, or other conduits, to resist fault displacement is generally not feasible. Only massive earth structures such as earthfill dams can be designed to remain functional after several feet of displacement along an underlying fault.

Permanent effects of surface displacements along faults also can include:

1. Abrupt elevation or depression of ground surfaces of several feet for distances of many hundreds of feet along the fault

2. Disruption of surface drainage

3. Changes in groundwater levels in wells

4. Blockage and surface seepage of groundwater flow

5. Changes in survey benchmark elevations

6. Dislocations of street alignments and property lines of many feet if lateral (horizontal) displacement also occurs along a fault, etc.

7. Displacement of drainage channels and drains

SECONDARY EFFECTS

Secondary effects of surface displacements along faults within an urban area could include:

1. Disruption of movement along roadways due to abrupt depressions or elevation of pavement surfaces.

2. Possible flooding due to disruption of drainage channel and storm drain flow.

3. Disruption of utility services such as water, gas, fuel, telephone and electric power lines.

4. Temporary impact on industry and commerce similar to that resulting from the occurrence of most kinds of regional natural catastrophic events such as hurricanes or floods.

GENERAL INVENTORY OF THE HAZARD

LOCATION AND HISTORY

The greatest potential for fault activity is along any of the faults which lie within the several major fault systems which transect the County from east to west. The recent San Fernando Earthquake which occurred along one of these major fault systems illustrates the high level of activity that some faults within these systems may have and foretells the future occurrence of other such earthquakes in the Los Angeles, Ventura-Santa Barbara region.

The San Fernando Earthquake of 1971 may be an example of the typical type which could occur along some of the east-west trending gaults which transect the County. Based upon that earthquake, it is most likely that a surface fault displacement within the County will be sudden, occurring over a period of less than one minute. The displacement would be accompanied by sharp earthquake shaking lasting perhaps several tens of seconds.

The following is a description of the major active and potentially active faults and fault systems within Ventura County (refer to Hazards Plate I):

Malibu-Santa Monica-Raymond Fault System

This fault system is believed to consist of a series of major north-dipping thrust faults which extend along the coast and onshore for a total of over 40 miles and perhaps a much greater distance offshore in the Santa Barbara channel. It begins in the San Bernardino area and extends along the southern base of the Santa Monica Mountains and passes offshore a few miles west of Point Dune.

Geologic evidence for activity of the fault system during recent geologic time up through the present are faulted Terrace and near surface sedimentary deposits, groundwater barriers and the recent Point Mugu Earthquake (February, 1973) which is believed to have originated on the Malibu Fault.

The faults within this system are considered active.

Simi-Santa Rosa Fault

This fault is associated with reverse or high angle thrust movement. From the Santa Susana Mountains westward along the northerly margin of the Simi and Tierra Rejada Valleys, along the south slope and crest of the Las Posas Hills to their westerly termination. The presence of the Springville and Camarillo Faults short distances to the north and south, respectively, of the westerly projection of the Simi-Santa Rosa Fault suggest a relationship to these faults which project into the Oxnard Plain along the trend of the subject fault.

Surface evidence north of Simi Valley indicates that at least the easterly portion of this fault has been active during Pleistocene time (11,000 to 3,000,000 years before present). However, available information is considered insufficient to conclude that westerly portions of the Fault have not been active during the Pleistocene or more recent time. No earthquake epicenters of magnitude 4.0 or greater (Richter Scale) have been recorded along the fault during historic time.

The fault is designated as potentially active until more information is available for evaluation.

Bailey Fault

This fault marks the boundary between the western Santa Monica Mountains and the Oxnard Plain. It extends from the Mugu Lagoon area northerly to an apparent intersection with the Camarillo Fault near Calleguas Creek and State Highway 101. The presence of the fault is based primarily upon water well data.

No evidence of surface expression of the fault is known nor have any earthquakes been recorded as having originated on it. The fault trace is obscurred by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

Camarillo Fault

This fault extends in an east-west direction immediately south of Camarillo from Calleguas Creek to the Oxnard Air Force Base. The presence of the fault is based primarily upon the apparent abrupt uplift along the north side of the fault linear uplift of the southern portion of Camarillo.

The apparent uplift of the north side of the fault is believed to be a surface expression of the fault. The fault trace, however, is obscurred by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

Sycamore Canyon and Boney Mountain Faults

These faults are the most prominent of a series of northeast trending breaks extending from the Point Mugu and south coast area to the Thousand Oaks area. The presence of the faults is evident by surface exposures showing displacement of sedimentary and volcanic rocks of pre-Pleistocene age. Younger rocks are not known to have been displaced by these faults.

Surface evidence of displacment of sedimentary and volcanic rocks of pre-Pleistocene age indicate that the faults have been active since despostion of those rocks. Younger rocks are not known to have been displaced by them. However, no specific investigations have been reported indicating that displacement of younger deposits has not occurred. Special areas of concern would be in the Potrero, Conejo, and Hidden Valleys and the Thousand Oaks area.

The faults are designated as potentially active until more information is available for evaluation.

Oak Ridge Fault System

The Oak Ridge Fault is a steeply southerly-dipping reverse or thrust fault which extends from the Santa Susana Mountains where it has been overridden by the north-dipping Santa Susana Thrust Fault, westward along the southerly side of the Santa Clara River Valley and thence into the Oxnard Plain. The relationship of possible westerly extension of the fault to the McGrath and offshore faults is unclear and may be complex. None of the faults beyond the westerly terminus of South Mountains have surface expression nor have any been shown to cut near surface sediments. It is conceivable that past movement of these faults in the Oxnard Plain area has not resulted in surface displacements but, instead, has resulted in only broad warping or tilting of the near surface alluvial sediments.

The Oak Ridge Fault System probably contains many branching faults and is believed to be associated with one or more faults of similar trend present in the Santa Barbara Channel

west of the Oxnard Plain. The system is over 50 miles long on the mainland and may extend an equal or greater distance offshore.

The rugged, steep terrain of the north slope of South Mountain suggests that at least that portion of the Oak Ridge Fault is active. The lack of surface evidence of fault displacement in the Oxnard Plain is not necessarily indicative of past activity in the recent geologic past as surface features could easily have been obscurred by fluvialite processes (erosion or deposition of alluvium). Several recorded earthquake epicenters in the offshore as well as mainland area during historic time may have been associated with the Oak Ridge Fault or others within close proximity and associated with it.

The fault system is considered active. Future information may result in portions being designated as inactive.

Ventura Foothills and Country Club Faults

The Ventura Foothills Fault has been postulated to exist along the base of the hills south of Sulfur Mountain extending from north of Saticoy westerly to the mouth of the Ventura River thence westerly an unknown distance into the Santa Barbara Channel area. The possible existence of this fault as well as the nearby Country Club Fault northerly of Montalvo is reported in "Geology, Seismicity and Environmental Impact." (1973), a special publication of the Association of Engineering Geologists.

Evidence for the existence of the Ventura Foothills Fault is based mainly upon minor faulting of Terrace deposits north of San Buenaventura and evidence of faulting from the Tidewater Oil Company corehole #5. The fault is believed to be north-dipping. The existence of the Country Club Fault is based mainly upon discontinuities of water wells located in the Saticoy vicinity.

At present, sufficient information to verify the presence of past or potential future activity of these faults is lacking.

Future studies will provide information regarding existence and potential activity of these faults. It is considered prudent, however, to acknowledge the presence of these faults and consider them as potentially active, at least until further information is available.

Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System

This fault system consists of a major series of north-dipping thrust faults which extend over 150 miles from Santa Barbara County into Los Angeles County. The system is associated

with an intense zone of folded and faulted bedrock. Relationships within the system become obscure over an 8 mile wide gap between the Red Mountain and San Cayetano Faults where these north-dipping faults give way to several large, south dipping faults.

Geologic evidence that the fault system should be considered active throughout its length is shown by location of earthquake epicenters (including the San Fernando Earthquake of 1971), groundwater barriers, and displaced alluvial sediments. In addition, the unusually high fluid pressures in the Ventura and San Miguelito oil fields are believed to indicate that tectonic stress has accumulated along that section of the fault system between the Red Mountain and San Cayetano Faults. It is possible that continued build up of this stress will eventually result in sudden release, probably in the form of an earthquake resulting from movement along one of more of the faults within the Ventura County portion of the system.

Research has shown that the San Cayetano Fault has 20,000 feet of displacement several miles east of Ojai Valley. The epicenter of an earthquake of magnitude 4.0 to 4.4 (Richter Scale) was located above the San Cayetano Fault between Fillmore and Piru.

The system is considered active.

Lion Mountain-Big Canyon Faults

These faults and several others present in the 8 mile gap between the Red Mountain and San Cayetano Faults dip southerly beneath Sulfer Mountain. The general area is complexly broken and folded by faulting which may be associated with the high fluid pressures (stress) present in the Ventura Oil Field to the south.

Although the general area of these faults has not experienced earthquake activity during historic time, their position within the Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System and the possible displacement of terrace deposits (Pleistocene time) indicates that they should be considered at least potentially active.

Arroyo Parida-Santa Ana Fault

This fault extends from Montecito to the Ventura River and probably along the south side of Ojai Valley. Evidence as to the direction of dip is conflicting.

Although no earthquake activity has been recorded during historic time the fault does apparently form a groundwater barrier in the alluvium beneath the Ventura River. On this basis, it

should be considered potentially active. Future information may require reclassification.

Santa Ynez Fault

This fault extends from Point Conception in Santa Barbara County, across the central portion of Ventura County, to near the east County line. It is considered to be one of the major faults in the region and is about 90 miles long. Past displacement has been about 10,000 feet of relative uplifting of the south side of the fault. The fault lies about 4 miles north of Ojai.

Left lateral displacement of streams crossing this fault has been cited as evidence for recent fault movement. Several earthquake epicenters have been located along this fault and one or two of these were in Ventura County. The strong 1927 earthquake centered west of Point Conception may have originated on the westerly, offshore extension of this fault.

This fault is considered potentially active until additional information is available for evaluation.

Faults Between the Santa Ynez and the North County Line

Several large faults occur in the mountainous area north of the Santa Ynez Fault and within Ventura County. The most significant of these faults are the Tule Creek, Munson Creek, Agua Blanca, Frazer Mountain and Big Pine Faults. Of these the more important appear to be the Pine Mountain Thrust and Big Pine Faults (9 and 16 miles north of Ojai, respectively). The Pine Mountain Thrust is north-dipping and favorably oriented for generating earthquakes in response to the north-south compressive forces which have triggered activity along such similar faults as the Malibu, San Fernando and San Cayetano.

Terrace deposits and stream channels have been offset by geologically recent movement along the Big Pine Fault. More importantly, it is reported to have ruptured the ground surface for a distance of 30 miles along its length during the northern Ventura County earthquakes of November, 1852.

Both of these faults are considered active.

San Andreas Fault

The San Andreas is the longest and most important fault in California. It transects a 4 mile section of the extreme northeast corner of the County, about 27 miles northeast of Ojai. It is the only fault within Ventura County which the

State has designated as being within a Special Studies Zone. Several Special Studies Zones have been established by the State Division of Mines and Geology along several of the major active faults within the State. Development proposed within these zones will require special site investigations prior to approval to insure that structures for human occupancy are not placed over a fault of fault branch. The State anticipates it will establish similar zones along other faults as funds become available for evaluation of potential activity.

Due to clearly established historical earthquake activity; this fault has been designated as active by the State Division of Mines and Geology. The last major earthquake generated along that portion of the fault which transects the northeast portion of the County was in 1857. The earthquake is estimated to have been on the order of magnitude 8.0 (Richter Scale) and would have caused considerable damage to structures in the southern County area had they been there. The occurrence of another such major earthquake along this fault is considered possible within the near future.

DEFINITION OF FAULT HAZARD ZONE

The fault hazard zones define a boundary where active or potentially active faults are believed to be located. These zones, based on available geologic data and the judgment of the County engineering geologist, are plotted on Hazard Plate I. Faults shown on the Fault Hazard Area Map, but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive.

The extent of Fault Hazard Zone boundaries are controlled by the traces of potentially active faults which are based on the best data available at the time the map was compiled. However, the faults shown on the maps were not field checked during the compilation of these maps. Because available fault data are highly varied in quality and the locations of some faults are known imprecisely, the zone boundaries have been positioned at a reasonable distance (about 660 feet or an eight of a mile) from the trace of the nearest potentially active fault. However, zone boundaries generally are more or less than 660 feet away from mapped faults because of 1) curved or multiple fault traces, 2) of the need to keep the number of turning points to a reasonable minimum, or 3) the quality of the data dictates a narrower or wider zone.

In many places the zone boundaries have been tentatively extended beyond the mapped limits of faults, such as occurs westerly of Camarillo and westerly of Saticoy. These zone extensions are considered necessary because, even though faults have not been mapped in these areas, it is considered

likely that extensions of known faults or branches of faults do extend into these areas. Future investigations or studies would be required for confirmation of any fault extensions.

The primary fault hazard zones designate areas which are believed to contain active faults. The secondary fault hazard zones include those faults for which less evidence is available concerning their potential for activity. More precise analysis requires further study. For the purpose of the Seismic Safety and Safety Elements, all primary and secondary fault hazard zones designated on Plate I should be considered equivalent to those established by the state for other faults within and outside of the County. No degree of relative potential for future surface displacement or degree of hazard is implied for the faults shown.

A fault is defined as a fracture or zone of closely associated fractures along which rocks on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement which may have taken place suddenly and/or by slow creep. A fault zone is a zone of related faults which commonly are braided and subparallel, but may be branching and divergent. It has significant width (with respect to the scale at which the fault is being considered, portrayed, or investigated), ranging from a few feet to several miles.

A fault trace is the line formed by the intersection of a fault and the earth's surface. It is the representation of a fault as depicted on a map.

Any fault considered to have been active during Quaternary time (last 3,000,000 years) - on the basis of evidence of surface displacement - is considered to be potentially active. An exception is a Quaternary fault which is determined, from direct evidence, to have become inactive before Holocene time (last 11,000 years). Such a fault is presumed to be essentially inactive and has been omitted from the map in most cases. Although faults shown on the maps may have been active during any part of, or throughout, Quaternary time, evidence for the recency of displacement is incompletely preserved and often is equivocal. In contrast, the State Mining and Geology Board, in their Policies and Criteria (adopted November 21, 1973), has defined any fault which has had surface displacement within Holocene time as "active and hence as constituting a potential hazard."

The following geologic time scale is provided for reference and perspective:

ILLUSTRATION 2 GEOLOGIC TIME SCALE
(abbreviated)

Geologic Age			Years before present (estimated)
Era	Period	Epoch	
CENOZOIC	QUATERNARY	"Historic"	200
		HOLOCENE	11,000
		PLEISTOCENE	2,000,000 – 3,000,000
	TERTIARY	PLIOCENE	7,000,000 – 10,000,000
		pre-PLIOCENE	65,000,000
pre-CENOZOIC time			
Beginning of geologic time			4,600,000,000

Faults defined as <u>active</u> by Policies & Criteria of the State Mining & Geology Board.

Faults defined as <u>potentially active</u> for the <u>purpose</u> of delineating special studies zones.

Source: State Mining and Geology Board

Uses and Limitations of the Hazard Zones

The best use of the fault zones is to define those areas within the zone as areas where special studies would be required prior to building structures for human occupancy. Such a criteria may require a developer or builder to evaluate specific sites within the zone to determine if a potential hazard from any fault whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Such studies should be required both for Primary and Secondary Fault zones. The latter should be included since future studies of these secondary zones could result in the redesignation of some of these to primary fault zones.

Users of the map should be fully aware that the zones are delineated to define those areas within which special studies may be required prior to building structures for human occupancy. Traces of potentially active faults are shown on the

maps mainly to justify the locations of zone boundaries. These fault traces are plotted as accurately as the sources of data permit; yet the plots are not sufficiently accurate to be used as the basis for set-back requirements.

Potentially active faults have been identified in a broad sense, although the evidence for the potential activity of some faults may be only weak or indirect.

The fault information shown on the map is not sufficient to meet the requirement for special studies. The onus is on the local governmental units to require the developer to evaluate specific sites within the special studies zones to determine if a potential hazard from any fault, whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Secondary Fault Hazard Zones designate areas which may contain faults which should be considered potentially active. Future studies as well as experience could result in redesignation of some of these areas to Primary Fault Hazard Zones. Special studies as required for Primary Fault Hazard Zones, should therefore continue to be required prior to approval of residential or other proposed permanent development within the Secondary Fault Hazard Zone.

Faults shown on the Fault Hazard Area map but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive. In general, they are not considered to be associated with the major regional potentially active fault zone trends. Special studies should, however, continue to be made of such faults prior to approval of any individual residential or other permanent developments which may be proposed over or in the near vicinity of any known faults.

SPECIAL STUDY ZONES

The extreme northeast corner of Ventura County lies within the Special Study Zone established by the State Geologist under the provisions of the Alquist-Priolo Special Studies Zone Hazard Act of 1972 for the San Andreas Fault transecting that area. New Special Study Zones have been established subsequent to the original county element along the Red Mountain Fault in the extreme western edge of Ventura County extending on to the offshore area of Santa Barbara County and along the Ventura Foothills Fault through the City of Ventura. Also, the San Cayetano Fault Zone extending from Ojai east past Fillmore, has also been designated as a Special Study Zone. Special Study Zone evaluations will be done on a number of the other faults in the County during the following one-to two-year period which will probably result in the Oak Ridge/Santa Susana Fault Zone along the south side of the Santa Clara River Valley being designated as a Special Study Zone and the Simi Fault Zone extending from Camarillo through the Santa Rosa, Tierra Rejada and Simi Valleys being designated as a Special Study Zone by the State Division of Mines and Geology.

NATURE OF INFORMATION

The intent of the Special Study Zone is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the erection of structures for human occupancy astride hazardous faults. However, the precise location and identification of faults within or near a zone of potentially active faults can be determined only through detailed geologic investigations. Therefore, the State Mining and Geology Board has adopted policies and criteria for the implementation of these zones.

The complete text of the policies and Criteria are in Appendix B. Its most significant criterion is that no structure may be built across the tract of an active fault. Furthermore, the area within fifty feet on either side of an active fault shall be assumed to be underlaid by active branches and, therefore, before any structure can be built within the zone, a geologic investigation and submission of a report by a geologist registered by the State of California are required. In addition, any city or county may require more restrictive policies.

The geologic information relating to the location of faults and their potential for activity is based largely upon past regional geologic studies conducted by universities and petroleum geologists as well as information compiled by the State Division of Mines and Geology and the County Department of Public Works. The most recent geologic information used was that covering the south half of the County which is contained in a report entitled "Geology and Mineral Resources Study of Southern Ventura County," Preliminary Report 14, 1973; prepared by the Division of Mines and Geology in cooperation with the County of Ventura Department of Public Works. The Seismic Hazard Study of Ventura County, California, designated as Open File Report 76-5 LA, prepared by the Division of Mines and Geology in cooperation with the Ventura County Planning Department and Ventura County Department of Public Works. In addition, there have been a number of small reports on specific areas as well as Fault Evaluation Reports on specific faults prepared by the Division of Mines and Geology.

The evaluative system utilized in estimating the potential of past activity of individual faults and fault systems is discussed under <u>General Inventory of the Hazard</u>. The basis and method of designation of the Fault Hazard Zones is similar to that used by the State Division of Mines and Geology in establishing the special Study Zones along active and potentially active faults within the State (see FAULT HAZARD ZONES section).

GENERAL MANAGEMENT RESPONSIBILITY

Investigation

Research and evaluation on the nature and mechanism of faults and fault activity is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a statewide basis. However, indirect benefit to Ventura County will be gained through developed technology.

Additional investigations are being conducted on a continuing

basis by:

Private Geologic Consultants who provide original information during investigations for private developments.

Ventura County Department of Public Works which:

a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated areas and for certain contract cities.

b) Performs geologic and soils engineering investigations for County projects such as road and flood control facilities.

c) Coordinates, evaluates and compiles geologic information for public and private investigations within the unincorporated areas and for certain contract cities. Private Geologic Consultants and City Engineers within the County.

Warning

Presently, there is no way to prevent or accurately predict when an earthquake and surface displacement is apt to occur along a

given fault. The state-of-the-art is such that at best, only the recency of past activity can be determined along some faults. In some cases, regional studies can indicate those systems of faults which may be potentially most active. In the Southern California area, those faults which have general east-west trends or are associated with the northwesterly trending San Andreas Fault are considered to be potentially the most active. There are indications that earthquake prediction will be possible in some areas of the United States in the near future. It is not known whether this will be one of those areas. However, there are serious social and economic problems with predicting earthquakes that must be evaluated before these predictions can be utilized when they are perfected. The National Science Foundation is presently instituting studies on these problems.

Alleviation

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of Planning
Public Works
Building & Safety
City Councils
Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be affected by the above agencies through requirements for review of proposed land uses and evaluation of investigations and engineering studies for private development or public projects. Such reviews and evaluations can be performed by qualified geologic and soils engineering staff or by retention of private consultants. Effective control of the fault hazard can only be achieved though knowledge of the location and potential for activity of faults and implementation of development controls within the hazard zones.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County planning departments can utilize available hazard information to avoid improper land uses. Decisions concerning adoption of these recommendations rest ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include port districts and redevelopment agencies.

Alleviation of existing hazards can be affected by removal of structures located over or strengthening structures in hazardous proximity to potentially active faults. Determination of whether structures are hazardously located would require detailed investigation of geologic conditions and of the potential for activity along any faults found.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The City of Moorpark along with the rest of the County of Ventura, lies within the seismically active region of Southern California and as characteristic of the region general is transected by many faults. Many of these faults are associated with major fault systems extending beyond the County boundaries. Several of these faults and fault systems are considered to be active and could have secondary affects upon the City of Moorpark. The nature of the fault displacement hazard is that it is extremely localized and directly affects only those structures which are built on or immediately adjacent to the fault trace itself.

Some of the more recent studies have indicated that a number of the faults in the County present a high enough degree of risk to be designated Specal Study Zones by the State Division of Mines and Geology. To be thus designated, there has to be fairly strong evidence that activity has occurred along these faults within Holocene time, at least the last 11,000 years. For the original County study, any faults which show a late Quarternary or Holocene movement have been designated as potentially active and/or indicated as primary hazard zones on the County Hazard Plates.

Within the City of Moorpark, the Simi Fault Zone has been designated as an active fault on the City Hazard Plate I, even though it was considered a secondary fault on the original County study. The Seismic Hazard Study of Ventura County of 1975 by the Division of Mines and Geology indicated a number of features which would be indicative of late Quarternary to Holocene fault movement. As indicated in the general portion of this text, the area will be considered for zoning as a Special Study Zone next year.

The Simi/Santa Rosa Fault system is a major regional trend which extends well east into Los Angeles County, a distance of over 27 miles. The faults that make up this system are mostly reversed faults with a steep dip to the north, although it lessens to a smaller dip in the Camarillo area. This fault has produced at least 6,000-7,000 feet of displacement in the lower tertiary deposits in the Santa Susana/Simi Valley area.

The fault has a number of youthful geomorphic features along the western part of Simi Valley and there is displacement of ground water bearing, late Quaternary sediments at the mouth of the Valley and by the Camarillo and Springville segments which indicates relatively recent movement. Fairly recent appearing geomorphic features also occur along the trace of the frontal fault in the Camarillo Hills along the north side of the Santa Rosa Valley and the north side of the Tierra Rejada Valley,

including the sag pond immediately west of the Moorpark Freeway. At the mouth of Tapo Canyon in Simi Valley, older alluvium is apparently displaced, but gradually to the east, especially east of County Line, fault movement seems to be less recent. The State Division of Mines and Geology and the Seismic Hazard Study of Ventura County indicate that the probable age of the movement was late Quarternary and that this fault could be capable of generating a magnitude 7 (major) earthquake.

In recent discussion (March 1986) Joe Hanna, Geologist with the County of Ventura's Public Works Agency, has indicated that recent studies of the Simi Valley Fault show probable displacement of late Pliestocene Tenaces and consequently, should be considered as "Active" or "Potentitally Active" until proven otherwise by onsite investigations.

Two splinters of this fault system are also designated as a primary fault hazard within the City. One following the Arroyo/Simi and a splinter fault connecting that fault near the College, south to the main Simi Fault Zone in the Tierra Rejada Valley and are indicated on the City Hazard Map Number 1.

The second area of faults is indicated on the County map as a single line in the Fairview area. Later investigation indicated this to be a number of small linear features which are southwest trending faults between the Oak Ridge and the Simi Zones. These extend into the Oak Ridge Zone at South Mountain. The features were not well defined or exposed, but they were investigated during a Fault Evaluation Report in 1977 by the State Division of

Mines and Geology which indicated that some of these faults may have been active during the Holocene, but without trenching and detailed investigation, definite proof was unlikely and recommended that these areas be further looked at when urbanization was proposed within that area. Therefore, these have been designated potentially active faults, but with a lower probability of major fault activity. The State indicated that they would have a maximum creditable earthquake of a 6 to 6.5 (severe, such as the 1971 San Fernando earthquake) range.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Damage from fault displacement is extremely localized directly along the fault. But any structures located over the fault would be damaged or destroyed by a movement. Probably much more destructive is the damage to infrastructure by fault displacement. Water lines, sewer lines and any other linear structures are effectively destroyed by even small movements along a fault line that they might cross.

Within the Simi Fault Zone, housing developments near the intersection of the new extension of Tierra Rejada Road and Moorpark Road actually intrude within the Fault Zone, although detailed studies would be needed to determine whether any structures were actually located over the fault itself. The

utility lines that have been placed within the new extension of Tierra Rejada Road and those in Moorpark Road would be affected by any movement along this fault line as well as most of major utilities crossing the western end of Simi Valley leading into Moorpark.

There is no question that the Simi Fault constitutes the major fault displacement hazard to the City of Moorpark. The fault to the north of the City in the Fairview area probably should be subjected to detailed subsurface analysis if there are any requested developments within the area traversed by the designated zone, since they do have a potential of being active fault traces.

FINDINGS

PROBABILITY OF OCCURRENCE

Available geologic information is not definitive about the potential for activity along the Simi Fault or the faults north of the City. However, common prudence would indicate that a structure should not be located directly over the fault trace or within a reasonable setback distance on either side. There is adequate information to indicate an earthquake along this fault could result in displacement of the surface features. The small

fault traces north of the City probably have a lower probability of occurrence of an earthquake as they are much less extensive.

SEVERITY OF THE HAZARD

Experience has shown that destruction of buildings placed over faults along which sudden surface displacement occurs is nearly total. Historically, the probability of any particular fault moving, with the exception of the San Andreas, is fairly small. During the life of any structure, the probability is virtually insignificant. Although the hazard is considered real, especially along the Simi Fault, the affect of the hazard is low compared to the likelihood of much greater damage which would occur as a result of a strong earthquake shaking caused by an earthquake on another fault.

RESOURCES AFFECTED

In the event of surface displacement along the Simi Fault, damage to utilities and perhaps to structures would occur in the area near the Tierra Rejada Valley. Another impact could be damage to the Simi and Moorpark Freeways which are the main links between the City, Thousand Oaks or Simi Valley. A displacement along the fault would also displace Tierra Rejada and/or Moorpark Roads, depending on the extent of displacement, exact location of the

break and the severity of the displacement that occurs.

The development that has occurred adjacent to the fault and within the General Fault Hazard Zone occurred before there was a general appreciation of the severity of the hazard along this fault. Detailed geologic investigations both onsite and regionally along the fault should be performed prior to further larger scale urbanization encroaching within the fault zone. Such investigations could either confirm Holocene movement or confirm that the movement is older than that and further precautions are not necessary. It could also establish a setback line for development.

In the small unnamed Fault Hazard Zone north of the City, good geologic investigations should be undertaken on each of these faults, both onsite at any development and in further areas along the trending zone to determine the fault's potential severity prior to any urbanization.

NATURE OF THE INFORMATION

Present information is not considered sufficiently accurate to warrant special investigation for most existing development. Consideration should, however, be given to reconfirming the safety of important, vital or emergency facilities, including

public utilities and roads where large numbers of people might be affected by a fault displacement. Further, more detailed information on fault locations may indicate further evaluation of some existing structures or facilities could be warranted.

Determination of the exact location of the faults or whether any other faults pass beneath or in the vicinity of the City would require detailed site investigations. Such analyses, however, are not within the scope of this study.

OTHER FINDINGS

Present controls in regard to land development within the City include the State Subdivision Map Act as well as various City ordinances and policies, including City grading, subdivision and building regulations.

Present controls are considered to be adequate for determination of the feasibility of proposed development in regard to geologic conditions and incorporation of appropriate design safeguards. Knowledge in regard to geology and design considerations is, however, constantly improving through research and experience and it should be anticipated that present requirements will be subject to improvement. Any critical utility facilities which cross a Fault Zone from north to south should be evaluated by the utility company. Additional information concerning these faults

will be available from the ongoing evaluation of faults by the State Division of Mines and Geology and by the County and private consultants which are constantly evaluating and updating their fault displacement information.

Present procedures for evaluating proposed projects are considered adequate and in keeping with present state laws and policies in regard to geologic considerations and incorporation of design safeguards for most land developments. Land use planning however, can be greatly improved in effectiveness through a greater knowledge of fault hazards, their location, nature and effects.

LEGEND

Faults Identified

Faults Conjectural

Hazard Area Min 50' From Center Of Fault

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE I

Fault Displacement

CITY OF MOORPARK

EARTHQUAKES & GROUND SHAKING

Safety Element
CITY OF MOORPARK

JSA

Oft the teeming earth
Is with a kind of colic pinched and vex'd
By the imprisoning of unruly wind
Within her womb; which for enlargement striving
Shakes the bedlam earth and topples down
Steeples and moss-grown towers.

Shakespeare
HENRY IV

GENERAL DISCUSSION

GENERAL DESCRIPTION

By far the greatest damage done by an earthquake is caused by the ground shaking, not the fault displacement. This section, therefore, is the companion section to the fault displacement hazard section. One of the very serious side effects of ground shaking is liquefaction, it is also covered as a separate hazard.

The probability of an earthquake is determined by a number of factors but basically by the location of active faults to an area and the tensional and compressional forces exerted against these faults.

California is interlaced with hundreds of active faults. The most important system is the San Andreas Fault which extends from south of Los Angeles to north of San Francisco. The main branch of this fault runs through the extreme northeast corner of Ventura County. This fault has been responsible for at least two major earthquakes; the San Francisco earthquake of 1906 and the Fort Tejon earthquake of 1857. The earthquake of 1857 is reported to have caused severe shaking in the, then undeveloped, southern portion of Ventura County.

In addition to the forces causing horizontal movement such as that predominant along the San Andreas Fault, Ventura County and portions of adjacent areas are subject to compressional forces acting in north-south directions. These latter forces tend to compress or try to shorten the distance from the San Andreas Fault south to the coast. The San Fernando Earthquake of 1971, resulting in the thrusting of the southern margin of the San Gabriel Mountains several feet southward over the north margin of the San Fernando Valley, was caused by these compressional forces. Several faults in Ventura County have been formed by and are related to these same forces (See Illustration 3.1). These fault systems are described in the Fault Displacement Hazard section.

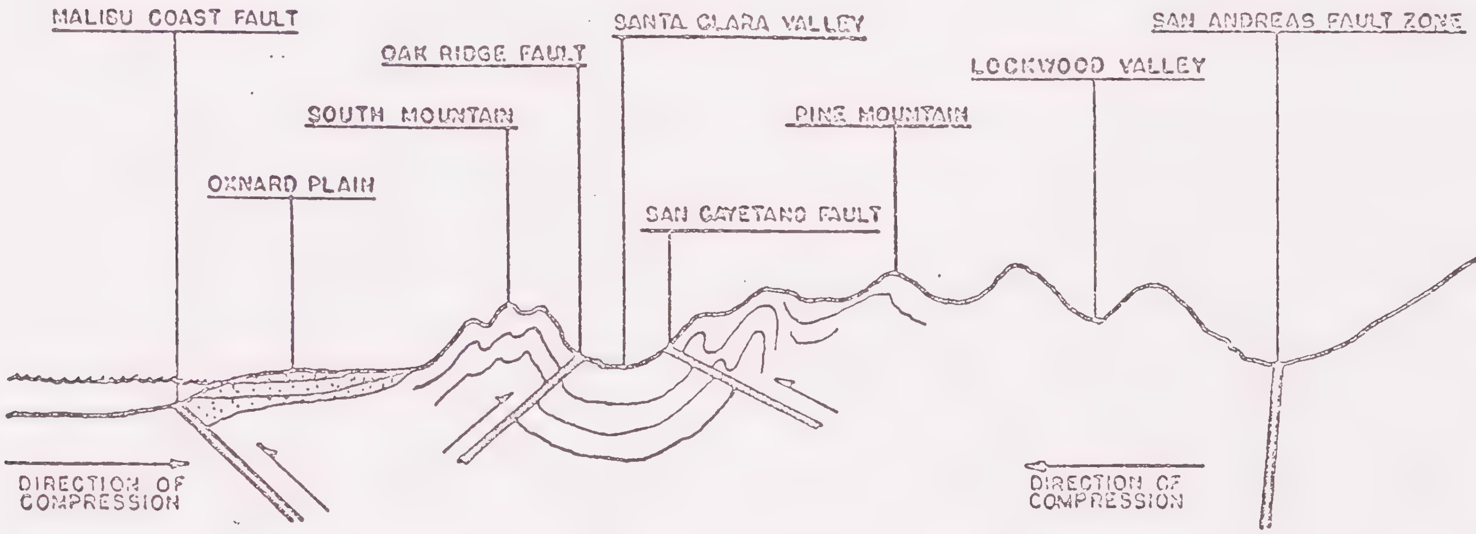
When an earthquake occurs, the break along the fault plane begins in a small area and rapidly propagates out along the fault planes. The point of first release of stress located below the earth's surface on the fault plane is called the earthquake focus. The point at the earth's surface vertically above the focus is the epicenter.

When a fault breaks, all of the accumulated strain energy is released as seismic waves. These waves travel

outward in all directions from the earthquake focus. Seismograms (records of earthquake motion) indicate that several kinds of motions are created by the passage of seismic waves. These motions can be classified as: Longitudinal Waves, Shear Waves, Rayleigh Waves, and Love Waves. Illustration 3.1 is a summary of the names and properties of the various types of seismic waves.

Illustration 1

A simplified north-south cross section showing the relationship of thrust faulting to presently active compressional forces.



SOURCE: Ventura County Public Works

Each of these waves has different types and directions of movement. Each can affect buildings slightly differently depending on many diverse variables. The combined effect of these waves makes up the ground shaking component of an earthquake.

In general, research of many past earthquakes indicates that the intensity of ground shaking at any given location during an earthquake is a function of several factors including:

1. Magnitude of the earthquake
2. Distance from the center
3. Depth at which the earthquake was generated
4. Type of ground motion
5. Geologic structure
6. Type of ground

Of these, the only variable which can be assessed very accurately in advance is the type of ground. Determination of ground response (ground wave motion) can

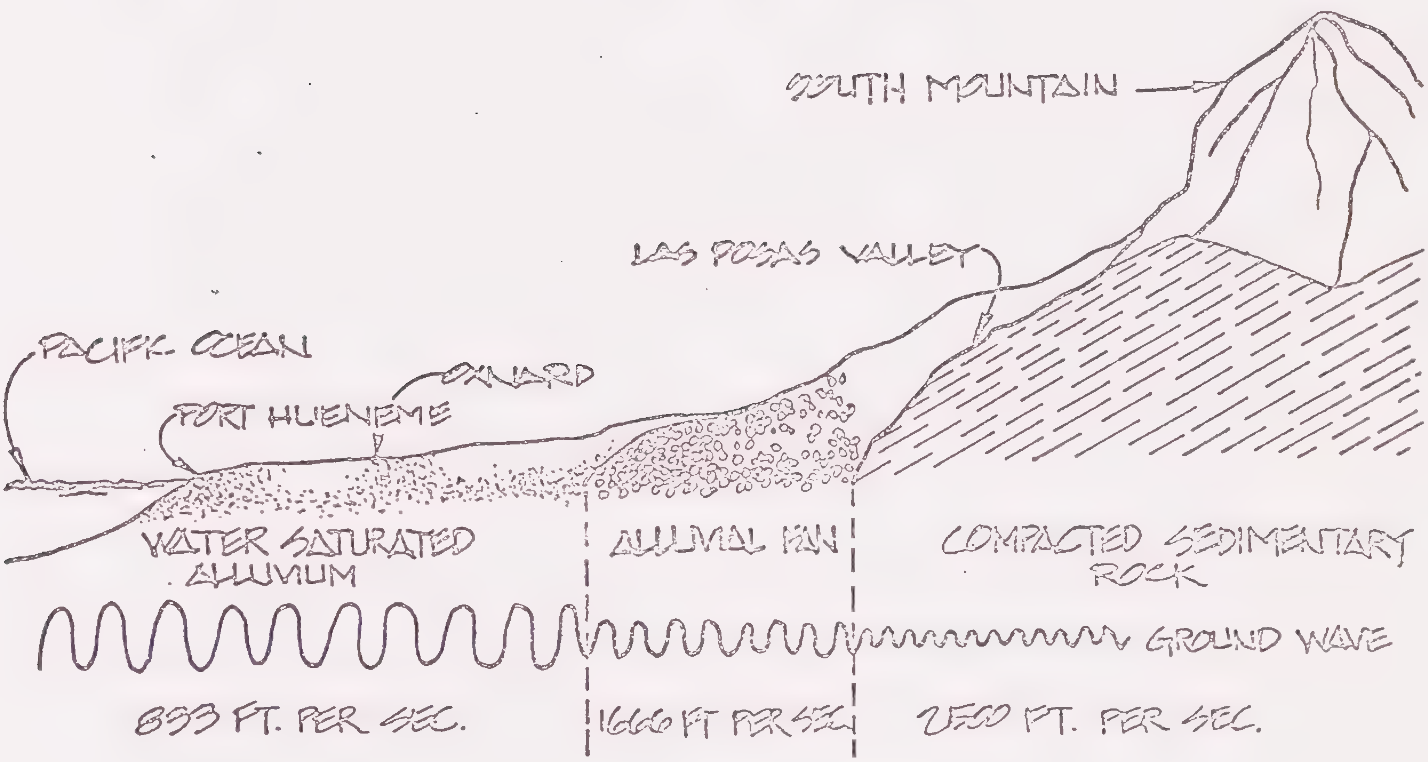
Illustration 2

NAMES AND PROPERTIES OF SEISMIC WAVES

Particle Motion Created by Passage of Wave	Synonymous Names of Waves	Standard Letter Designation in Seismology	Names Based on Travel Paths in Earth
Oscillation along lines in direction of wave travel	Longitudinal waves Compressional waves Push-pull waves Sound waves	P (for Primary)	Body waves
Oscillation along lines at right angles to direction of wave travel	Shear waves Transverse waves Shake waves	S (for Secondary)	
Around in circles lying in vertical planes; in same direction as wave advance under troughs, in opposite direction under crests	Rayleigh waves	L (for Large)	Surface waves
Oscillation at right angles to direction of wave travel along lines lying in horizontal planes	Love waves		

Source: Longwell and Others, 1969, p. 432.

Illustration 3 Change in speed of ground wave as it enters different materials, with a concurrent increase in amplitude.



be estimated based largely upon existing earthquake records, though only for a predicted location and magnitude of an earthquake.

The intensity of ground shaking during an earthquake depends in large part on geologic foundation conditions, i.e., the thickness and physical properties of the materials comprising the upper several hundred feet beneath the area. In general, the greatest amplitudes and longest durations of ground shaking usually occur on thick, water-saturated, unconsolidated alluvial sediments. Recent studies of groundmotion in San Francisco generated by underground nuclear explosions in Nevada indicated that the peak groundmotion velocities were as much as 10 times larger on soils adjacent to the bay than on nearby bedrock.

Illustration 3.3 is a diagram of the area from South Mountain near Fillmore to Port Hueneme which shows the slowing down of the ground wave as it passes from consolidated sedimentary rocks on South Mountain to the alluvial fan materials of the Las Posas Valley along with a corresponding increase in wave amplitude. An increase in wave amplitude generally means an increase in intensity of ground shaking. There is even a more marked decrease in speed and increase in amplitude between the alluvial fan materials of the Las Posas Valley and the water saturated sediments of the Oxnard Plain.

Two separate indexes, or scales are commonly used in the United States in describing seismic or earthquake disturbances. The qualitative rating of the degree of earthquake shaking based upon feeling and visual observation is indicated by an intensity scale. The size or energy release of earthquakes is measured by a magnitude scale.

Measurement of the radiated energy released by an earthquake was originally proposed by C.F. Richter in 1932 and utilizes a system of tables and charts to deduce from seismological instruments a method of measuring the magnitude of an earthquake. The magnitude assigns a number to the calculated energy release, this system can rank earthquakes and compare them one to the other. By this method, an earthquake is rated independently of the place of observation.

The magnitude is the logarithm (base 10) of the maximum amplitude of a seismogram referred to a distance of 100 kilometers (62 miles) from the epicenter. Under this system, an increase of one unit in magnitude is equal to 32 times the next lower degree of energy release. Thus an earthquake of magnitude 7 represents about 32 times as much energy release as one of magnitude 6;

magnitude 8 represents 32 times the energy of magnitude 7 and, therefore, about (32 X 32) 1000 times the energy of magnitude 6.

The other index is much more of a reflection of the damage caused by ground shaking as it measures effects. It varies from place to place, not necessarily in direct relationship to the distance from the earthquake. The intensity is more or less independent of the magnitude.

The scale used to measure the intensity of an earthquake is the Modified Mercalli Scale with intensities ranging from I to XII (See Illustration 3.4). The scale is a description of the physical effects of earthquakes. The lowest intensity ratings are based on human reactions, such as "felt indoors by few." The highest intensities are measured by geologic effects, such as "broad fissures in wet ground, numerous and extensive landslides, and major surface faulting." The middle intensity range is based largely on the degree of damage to buildings and other man-made structures. Intensity ratings are based on visual observation and are not measured with instruments. The degree of intensity varies from place to place during an earthquake. Specific locations in an area may have an intensity rating of VIII because of soil conditions, structural design, or distance from field epicenter. Intensity scales have generally been replaced by more quantitative measures such as the magnitude scale and ground response based upon seismograph or accelograph records.

An important factor affecting the degree of damage to structures during an earthquake is the frequency characteristics of groundmotion as related to the fundamentl periods of vibration of the structure. For sites such as the plain area which are underlain by deep deposits of unconsolidated alluvium, the peak values of the acceleration response spectra tend to occur at high values of the fundamental period, resulting in high (damaging) accelerations being induced in flexible structures such as multi-story buildings. The reverse is true of the area underlain by firm bedrock, i.e., the high accelerations would be induced in rigid structures such as reinforced buildings of only a few stories in height.

In general, the greatest damage to tall structures results where they are built over thick, soft, water-saturated sediments. The least damage occurs where they are built on very firm bedrock. The structural integrity of buildings before the earthquake and whether the natural vibration period of the structure is coincident to that of the ground are both factors that complicate these general concepts.

When the building and the ground approach the same vibration period, the greatest damage is likely to occur. The predominant vibration period of a building can be related in a very general way with its height or number of stories. Taller buildings have a longer predominant vibration period (2 or more seconds). Therefore, they are subject to greater damage where they occur on ground with a longer predominant vibration period (thick, water-saturated sediments). Conversely, 1 or 2 story buildings with short predominant vibration periods on firmer ground may be in trouble. Other factors which contribute to damage potential, such as magnitude, distance, frequency and duration of a particular earthquake, influence the predominant vibration period. For the Ventura County area,. unfortunately, none of the factors are predictable with any great degree of confidence.

Intense ground shaking in areas of unconsolidated, water-bearing sediments (alluvium) or wet soils could also result in soil liquifaction, ground rupture, lurching, slumping and lateral movement of nearly level areas and landsliding. The greatest hazard of gound failure in hillside areas is in the form of landsliding and other slope failures. Seismic shaking can renew movement of old landslides as well as result in formation of new slides. Many of the existing landslide features may have been triggered by past earthquake shaking. The combination of relatively weak bedrock, deep weathering, steep slopes and inclined bedding combine to make many areas highly susceptible to landslide failure during seismic shaking.

Illustration 4

MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES

MODIFIED MERCALLI INTENSITY SCALE OF 1931

The first scale to reflect earthquake intensities was developed by de Rossi of Italy, and Forel of Switzerland, in the 1880s. This scale, with values from I to X, was used for about two decades. A need for a more refined scale increased with the advancement of the science of seismology, and in 1902 the Italian seismologist, Mercalli, devised a new scale on a I to XII range. The Mercalli Scale was modified in 1931 by American seismologists Harry O. Wood and Frank Neumann to take into account modern structural features:

I Not felt except by a very few under especially favorable circumstances.

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated.

IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII Everybody runs outdoors. Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.

IX Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.

The Modified Mercalli intensity scale measures the intensity of an earthquake's effects in a given locality, and is perhaps much more meaningful to the layman because it is based on actual observations of earthquake effects at specific places. It should be noted that because the data used for assigning intensities can be obtained only from direct firsthand reports, considerable time—weeks or months—is sometimes needed before an intensity map can be assembled for a particular earthquake. On the Modified Mercalli intensity scale, values range from I to XII. The most commonly used adaptation covers the range of intensity from the conditions of "I—not felt except by very few, favorably situated," to "XII—damage total, lines of sight disturbed, objects thrown into the air." While an earthquake has only one magnitude, it can have many intensities, which decrease with distance from the epicenter.

The following are excerpts from a manuscript in preparation by D.R. Nichols, U.S. Geological Survey.

Ground Shaking - Probably the most difficult task today, in terms of the predictive capability of the geologist and seismologist, is devising a reasonably reliable method of predicting "ground shaking" effects --what most people and structures react to during an earthquake. Examination of damage from numerous past earthquakes, in lieu of conclusive strong-motion seismograph records, has suggested to geologists and engineers that the greatest damage to tall structures results where they are built over thick, relatively soft, water-saturated sediments and that the least damage occurs where they are built on very firm bedrock. Although engineers have shown that while great thicknesses of wet unconsolidated sediments may amplify the ground motion, perhaps a more critical measure of damage is a determination of the "predominant period" of the building and of the ground on which it rests. The predominant period of a building can be related in a very general way to its height or number of stories. Taller buildings have a longer predominant period (2 seconds or more). Therefore, they are subject to greater damage where they occur on ground with a longer predominant period (thick, saturated sediments). Conversely, one or two-story buildings with a short predominant period may be in trouble on firmer ground. Further complicating this very generalized picture are a wide variety of other factors that may contribute significantly to a damage potential: magnitude of a particular earthquake, distance and direction from the epicenter and causative fault, duration of shaking and the structural integrity of buildings before the earthquake, and many others. The greatest damage is likely to occur where the predominant ground period is coincident with that of the greatest number of high-rise buildings. However, a prediction of ground shaking at a particular spot or point is subjec to a great variety of conditions, only some of which are predictable with confidence. For example, a magnitude 5 earthquake on the San Andreas Fault at Hollister may have the same damage pattern at a particular locality as a more distant 7.5 magnitude earthquake on the Hayward or Calaveras fault.

Ground Failure - Earth materials in a natural condition tend to reach equilibrium over a long period of time. In geologically active areas such as California and Alaska there are many regions where earth materials have not yet reached a natural state of stability. For example, most of the valleys and bay margins are underlain by recent loose materials that have not been compacted and hardened by long-term natural processes. Landslides are common on most of the hills and mountains as loose material moves

downslope. In addition, many activities of man tend to make the earth materials less stable and hence to increase the chance of ground failure. Some of the natural causes of instability are earthquakes, weak materials, stream and coastal erosion, and heavy rainfall. Human activities that contribute to instability include oversteepening of slopes by undercutting them or overloading them with artificial fill, extensive irrigation, poor drainage or even groundwater withdrawal, and removal of stabilizing vegetation. These causes of failure, which normally produce landslides and differential settlement, are augmented during earthquakes by strong ground motions that result in rapid changes in the state of earth materials. It is these changes, by means of liquifaction and loss of strength in fine-grained materials, that result in so many landslides during earthquakes as well as differential settlement, subsidence, ground cracking, ground lurching, and a variety of transient and permanent changes in the ground surface.

Mechanisms of Failure - Liquifaction is a common mechanism causing many types of ground failure. It occurs when strength of saturated, loose, granular materials (silt, sand, or gravel) is drastically reduced, such as may occur during an earthquake. The earthquake-induced deformation transforms a stable granular material into a fluidlike state in which the solid particles are virtually in suspension similar to quicksand. The result, where the liquified materials are in a broad buried layer, may be likened to the action of ball bearings in reducing friction in the movement of one material past another. The Juvenile Hall Landslide during the 1971 San Fernando earthquake resulted from liquifaction of a shallow sand layer and involved an area almost a mile long and a failure surface that had a slope of only 2-1/2percent (Youd, 1971, p. 107, 108). Where the liquified granular layer is thick and occurs at the surface, structures may gradually sink downward. The tilting and sinking of buildings during the Niigata earthquake illustrate this phenomenon.

Results of Ground Failure - Although the basic causes of ground instability are simple in concept, the consequences are often complex and highly variable. They include numerous varieties of landslides, ground cracking, lurching, subsidence, and differential settlement. Moreover, these types of ground failure occur on a wide variety of ground conditions. Landslides, for example, do not require a steep slope on which to form, particularly during earthquakes. Many occur on slopes that are virtually flat, and the surface on which they fail may be very shallow (1 to 2 feet deep) or as much as hundreds of feet below the ground surface. The type of ground failure that develops in a given area is determined by the nature of the natural or man-made disturbance that occurs and partly by the topographic, geologic, hydrologic, and geotechnical characteristics of the ground.

Ground cracking usually occurs in stiff surface materials and is associated with changes in surface topography or materials. For example, during the 1964 Alaskan earthquake, much of the ground cracking that occurred along river flood plains adjacent and parallel to stream channels and along road and railroad embankments resulted from differential movement owing either to liquifaction or to lateral spreading of a relatively soft, deeper layer under a stiffer surface layer. Cracks may be only hairline or several feet wide and from a few feet to hundreds of feet long.

Ground lurching may be both a transitory and permanent phenomenon. During earthquakes, soft saturated ground may be thrown into undulating waves that may or may not remain when the ground motion ceases. The same or similar ground surface appearance may also result from permanent differential settlement of the ground, which can be caused by loss of soil strength or by liquifaction. Commonly, the water freed by liquifaction of buried and confined granular layers is forced to the ground surface, moving laterally toward steep slopes or vertically along the planes of weakness in the overlying layers. As the water moves toward the surface or "free face," it often carries with it some of the sand. Thus, "sand boils," "sand volcanoes," "sand ridges," and similar anomalous features attest to the occurrence of liquifaction. As sand and water are removed from the subsurface, the ground settles, often differentially because the sand and water are seldom removed evenly over broad areas. The resulting effects on buildings can be catastrophic.

Subsidence of as much as several feet mav occur over a broad area underlain by a thick sequence of sedimentary deposits. For example, after the 1906 earthquake, a well casing was reported to have "risen" two feet out of the ground, when, in fact, the ground around it probably liquified or compacted as a result of the shaking. Subsidence is likely to be greatest in areas where there has been withdrawal of fluids (ground water or oil) over a long period of time. Lesser amounts of subsidence can occur even where fluid withdrawal has not taken place, as in the Homer area of Alaska in 1964. Compaction effects may be predicted with some degree of assurance over fairly broad areas (up to 1 or 2 miles) and even on a site basis, expecially when the cause may be liquifaciton.

Tectonic Deformation - Earthquakes may produce major differential vertical and horizontal movements over broad parts of the earth's crust. For example, as a result of the 1964 Alaskan earthquake, between 70,000 and 110,000 square miles of both the sea floor and land in southern Alaska were warped, elevating or depressing them as much as 6 feet; elevation changes locally exceeded 50 feet

(Hansen and others, 1966, p. 17). While the effect of compaction and tectonic subsidence may appear the same locally, the mechanisms differ greatly and the total area affected will be much greater where tectonic deformation occurs. Tectonic land changes result from major movements in the earth's crust, and neither their location nor their magnitude is predictable. Therefore, little can be done to minimize the effects of these changes before they occur.

All of Ventura County lies within the highly active earthquake region of Southern California. Preliminary estimates by R. Greensfelder (California State Division of Mines and Geology, unpublished preliminary research information) indicate that most of Ventura County can be subject to as strong earthquake shaking as can be expected anywhere in California. Only the area of the Santa Monica Mountain is estimated to have slightly less severe ground shaking potential.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

The primary effect of ground shaking is the damage or destruction of structures and infrastructures and thus the potential for the loss of life or sustaining injuries. The severity of the effect is dependent on many factors such as the strength and design of the structure to withstand shaking; composition and depth and the geologic structure of underlying earth materials; the presence of free groundwater and the topography. In general, all structures in areas subject to ground shaking will be affected.

Damage to structures during ground shaking can range from minor cracking of plaster to total collapse and or overturning. No structure can be assured to be designed and constructed to withstand damage from a strong earthquake. Some damage, whether it be to the structure or its contents, can be anticipated.

Ground shaking could cause severe damage to most utilities including pipelines, power lines, generating and convertor facilities, roads and bridges, if such structures were not constructed to withstand the shaking. Ground surfaces could rupture, crack and subside up to several feet in areas of unconsolidated alluvium resulting in damage to structures located in these areas.

SECONDARY EFFECTS

As a result of severe shaking and structural failures there are other secondary effects possible. Such effects include:

1. Cost of rehabilitation
2. Disruption of utilities and services for a substantial length of time
3. Seiches
4. Liquefaction
5. Possible sympathetic movement of other faults
6. Temporary and long term psychological effects
7. Adverse affect on the quality of water in ground water aquifers.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hazard exists throughout Ventura County and may significantly increase, wherever there is ground material that could significantly amplify the ground waves of an earthquake and produce high intensity ground shaking. Every place in the surrounding area would be shaken by an earthquake, the area affected would generally be determined by the magnitude of the earthquake. Those areas that might be shaken more than others are in the hazard zones. (Shown on Hazard Plate II).

The highest amplification of ground shaking occurs in areas where the long period wave shaking is greatest, designated as Area A on Hazard Plate II. Basically, this is the Oxnard Plain and the Santa Clara River in the south half of the County and in Lockwood, Cuyama, and Cuddy Valleys in the north half. Areas that could experience some amplification of long period shaking generally surround these areas and extend up the canyons of the major rivers and creeks.

The areas with the greatest amplification of short period shaking are along the base of the hills and in minor river valleys and in the broken bedrock along fault lines such as the San Cayetano and Simi-Santa Rosa Faults. Slight to moderate amplification of short period oscillations may occur on terrace deposits or soft bedrock, which has a thin soil covering. These materials are found in young hill areas such as South Mountain, Oak Ridge, Sulphur Mountain, and the north coastal hill lands and the Piru area in the south half of the County. In the north half these are along the margins of the valley areas such as Hungry and Lockwood Valleys and hill lands north of Cuyama.

HISTORY OF THE HAZARD

Southern Ventura County

The southern County area is considered that portion southerly of the east-west projection of Nordoff Ridge located immediately north of the Ojai Valley. Even though the historic record indicates that no strong earthquakes or surface displacement have occurred along the faults within the southern county area, the likelihood of the occurrence of one or more of such events within 50 to 100 years is not remote. The recent San Fernando earthquake occurred along a fault having little historic record of activity. Several of the faults within the south half of Ventura County, such as the Santa Susanna and San Cayetano, are similar in structure and subject to similar tectonic forces. Crustal deformation resulting in similar earthquakes will likely continue into the indefinite future.

The history of strong earthquakes provides an indication of what will probably occur in the future, however, the record does not provide a statistically sound basis for prediction. It is probable that earthquakes of magnitude 6 and larger will occur in the future within the south half of the county area or in the nearby offshore areas, and it would be consistent with past experience if several such shocks occurred in the next century. Surface displacement associated with the earthquakes is also possible.

The following is a portion of the summary of faulting and seismicity of the southern County area taken from the "Geology and Mineral Resources Study of Southern Ventura County" (1972) prepared by the State Division of Mines and Geology in cooperation with the Ventura County Department of Public Works:

"The earthquake history of Ventura County, particularly of the more populous southern part, is dominated by small to moderate shocks. Many of these shocks have been severe in their local, epicentral areas, but regionally have caused only light damage. No earthquake greater than magnitude 4.7 has been recorded in Ventura County, or the immediate offshore area, since 1934 when adequate instrumental records became available. These relatively minor shocks have caused local damage but no recorded loss of life. A review of the earlier less accurate record from 1769 to 1934 suggests a similar history for the southern County region. More serious than effects from local shocks have been the effects from relatively numerous moderate to large earthquakes whose epicenters are located outside of southern Ventura County. These shocks have caused considerable damage but no recorded loss of life.

Several larger, historic earthquakes are especially important to the evaluation of future seismic risk in

southern Ventura County. On December 21, 1812, an earthquake, probably located offshore south of Santa Barbara, damaged missions from Purisima Concepcion, near Lompoc, to San Fernando on the south. The tower of the San Buenaventura Mission was wrecked and much of the facade had to be rebuilt. This earthquake was accompanied by seismic sea waves which had reported runup heights of 30 to 50 feet between Santa Barbara and Gaviota and 15 feet or more at Ventura (Wood and Heck, 1966). Such waves today would do considerable damage to many parts of the now heavily settled coastal areas of Ventura County.

On January 9, 1857, the great Fort Tejon earthquake, with its epicenter probably on the San Andreas fault, close to the northeast corner of Ventura County, caused significant damage in the southern part of the County. The roof of the Mission Church at San Buenaventura fell in (Townley and Allen, 1939). Six miles from the south of the Santa Clara River the bed of the river was severely cracked. Wood (1955, p. 53) quoted a report describing the cracks as "being six or eight inches across, and extending in a direction SE and NW." Quoting further he said that "on either side of the cracks lay a ridge of wet sand." These cracks were probably due to lurching and liquifaction in the saturated alluvium of this area.

Wood continued, noting:

> *These appearances were visible as far as I could see up and down the bed of the river. Near the mouth of the river the cracks were longer and wider. Persons residing within a mile of the entrance say that the water was thrown out from the cracks as high as six feet, and that large blocks of earth sank several feet below the former level, and there remain.*

A second important earthquake is the June 6, 1925 shock of magnitude 6.3, which destroyed the business section of Santa Barbara and caused some damage in Ventura. An offshore shock on June 30, 1941, magnitude 5.9, cracked some walls and plaster, broke windows and dishes and damaged considerable shelf-stock in some stores in Ventura.

The intensity of shaking reported in much of Ventura County from the February 9, 1971, San Fernando earthquake was sufficient to cause minor damage and to cause breakage of some goods thrown from store shelves. In Santa Susana, some older buildings were severely damaged, with at least one or two razed. At least a few rockfalls and one small bedrock landslide occurred north of Simi Valley in the Tapo Canyon area, just south of the Santa Susana fault. Small displacement occurred on this fault during the

earthquake in the northwestern Sylmar area. The fault extends west, where it joins the Oak Ridge fault and possibly the San Cayetano fault system in the Piru-Oak Ridge area.

The questions, "which faults of southern Ventura County are active or potentially active?" has not been answered fully. The Red Mountain and San Cayetano thrust fault zones, which together nearly span the County (See Hazard Plate I), should be considered active. Holocene and Pleistocene sediments are displaced by the Red Mountain thrust, and similar physiographic features on both the Red Mountain and San Cayetano thrusts, also suggest Holocene displacement. In addition, aerial photos show many ground surface lineaments and other phenomena which may reflect Holocene or later Quaternary faulting, and should be investigated. One alignment near the base of the Ventura Foothills, roughly corresponds to a fault shown in cross section by Ogle (1969), who correlates it with the offshore, Pitas Point fault.

Several reverse faults, which apparently act as barriers to ground water in the alluvial areas, were also probably active during the late Quaternary, as described by California Water Resources Board (1953). These include the Springville fault at the western Simi Valley area, the western Oak Ridge (Saticoy) fault in the Oxnard Plain area, and the Santa Ana fault in the Oak View area (a fault zone which has raised the Upper Ojai Valley relative to Ojai Valley). The Camarillo fault may not act as a ground water barrier, but California Water Resources Board (1953, p. B34) stated that the fault may have offset alluvium.

A problem in southern Ventura County equally as serious as the identification of active or potentially active faults is the problem of identifying the geologic units as to their seismic response characteristics. For example, Richter (1959, p. 143) stated that much of the alluviated area of the Santa Clara Valley and the Ventura basin should expect shaking sufficient to cause considerable damage in specifically designed buildings and great damage to normally substantial buildings. In the eastern part of the Ventura basin this was demonstrated during the San Fernando earthquake. The expected damage to areas where ground water is within 15 feet of the surface could be even greater, but would be relatively less in areas underlain by older alluvium and even less on more indurated or cemented Tertiary rocks. Older landslides may be reactivated or new landslides may originate in some areas of Tertiary rocks of the County during an earthquake. Especially landslide prone is the Pico Formation, and to a lesser extent the Modelo/Monterey and Rincon Formations."

Northern Ventura County

The most important faults in the vicinity of the northern County area are the San Andreas, Big Pine, Garlock, San Gabriel and Frazier Mountain thrust, all of which converge at the northeast corner of Ventura County, and the Santa Ynez in the southern part of the north half of the County. All of these faults except perhaps the Frazier Mountain thrust are considered to be active, i.e., are potential focal points for the occurrence of earthquakes and displacement of the ground surface. Other mapped and unknown faults within the north half may also prove to be active by future displacement or detailed investigations.

Historic Record - Reliable accounts of California earthquakes date from about 1800. Since that year it is estimated that 35 to 40 earthquakes of magnitude 6.0 (Richter Scale) or larger have occurred in southern California. Over 20 of these occurred since 1912. Three of the earthquakes could have caused substantial damage to major structures in the north half had such structures been located there. These three earthquakes were the Northern Ventura County of 1852, Fort Tejon of 1857 and the Kern County of 1952.

The Big Pine fault, a major left-lateral fault with some oblique slip (subject to both horizontal and vertical displacement), may have had measurable movement during historic time. The earthquakes (apparently several) of November 1852 were accompanied by about 30 miles of surface faulting in Lockwood Valley. The exact location of the surface breaks is unknown, but geologic evidence and reports by others indicate that it may have been along the Big Pine Fault. Evidence of young movement along the fault includes scarplets that cut terrace deposits and apparent left-lateral offset of stream channels.

Several other faults found in the Lockwood Valley area have had recent movement by virtue of their cutting of terrace deposits and offset of other faults. These faults range from several hundred to a few thousand feet in length. Some of them indicate the region has recently undergone, and is probably still undergoing, compression along north-south directions.

Future Earthquake Potential - The historic record shows that the north half has experienced several severe shocks originating along faults both within and immediately outside of the area. The geologic record shows that a high level of tectonic activity has continue to the present time.

The history of severe earthquakes provides an indication of what will probably reoccur in the future,

however, the record does not provide a statistically sound basis for prediction. It has been found, however, that the number of large earthquakes that occur in a region is related to the number of small earthquakes.

Movement of the land mass west of the San Andreas fault relative to the east side, has been fairly well substantiated by the geologic record as well as precise surveying, and is about 2 inches per year. That portion of the San Andreas fault immediately north of the County has not shown displacement since 1857 nor has any been reported along the Big Pine or other faults in the north half since 1852.

Geologic and survey evidence indicates that stress is building up along the San Andreas fault to the north. It is just a question of time until the fault in this area again displaces with a high probability that the resulting earthquake will be severe. Prediction of when displacement will occur is not possible at this time, however, it is likely that it will occur within 100 years and possibly much sooner.

Earthquakes and surface displacement originating along faults within the north half is also highly possible, but again, prediction of when is not possible. Determination of the potentially most active faults would require extensive field investigation and was not completed during this study. However, previous studies and published information indicates that many recently active faults may exist within the region. In addition, the apparently active compressional forces which continue to affect the area, as recently reflected by the San Fernando earthquake, provide the means through which future earthquakes could occur along the known as well as other presently unknown, faults within the area.

Since 1852 the northerly portion of the north half has experienced severe shaking probably on the order of XI on the Mercalli Modified Intensity Scale during three earthquakes. One of these may have been centered on the Big Pine Fault during which rupturing of the ground surface occurred. Earthquakes of equal or greater intensity can be expected to affect the area in the future, and it would be consistent with past behavior if at least two such events occurred in the next century. It is likely that at least one of these events will be centered along the nearby San Andreas fault.

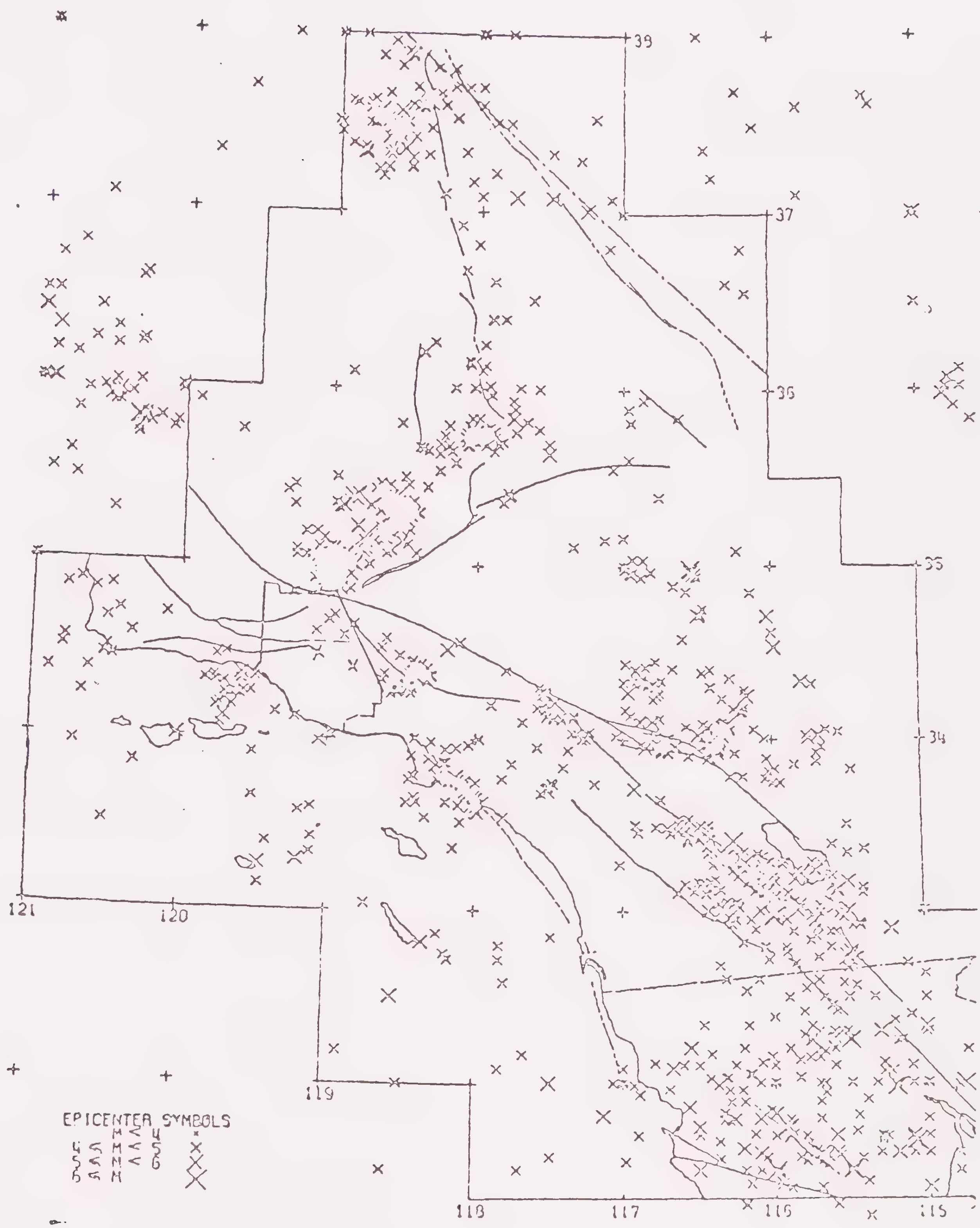
A large earthquake (7.0 magnitude or greater) in the vicinity of the north half would cause intense shaking with possible ground deformation and rupturing in valley alluvium, man-made fills and marginally stable hillsides. The resulting damage to structures would be great especially

during the wet season when groundwater is at its highest level of in areas where groundwater is being recharged by lakes or surface irrigation.

It is impossible, based upon the meager available information and experience with earthquake activity in California, to accurately predict the degree of shaking which could result from a great earthquake such as those of the not so distant past which affected the region. However, itis not unreasonable to expect bedrock accelerations of over 1.0g (or equivalent to the acceleration of gravity) and over 45 seconds of maximum shaking duration. The degree of shaking would, of course, be much greater resulting in higher accelerations, in areas underlain by alluvium or valley sediments. Peak bedrock accelerations in the range of 0.5g to 1.0g were recorded during the relatively small San Fernando Earthquake of 1971.

Illustrations 3.5 - 3.7 indicate the approximate number, epicenter and magnitude of earthquakes recorded in the vicinity of Ventura County since 1932.

Illustration 5
REGIONAL EPICENTER MAP 1932-1971



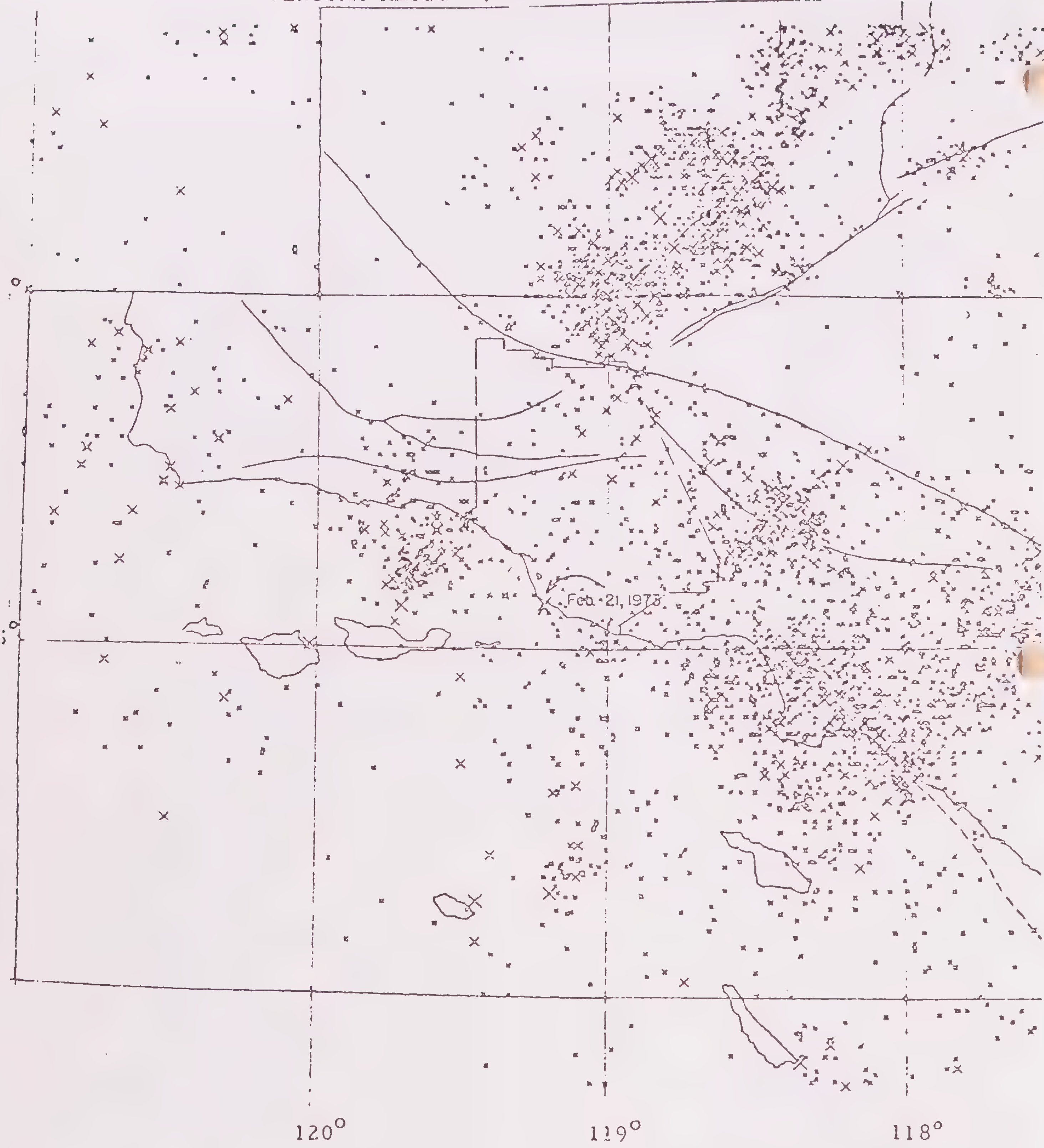
Note: Earthquakes less than magnitude 4.0 not plotted

0 100 miles

Ref: Unpublished thesis material by James A. Hileman, California Institute of Technology, 1972.

Illustration 6

VENTURA REGION (all events 1932-1972)



EPICENTER SYMBOLS

M < 4

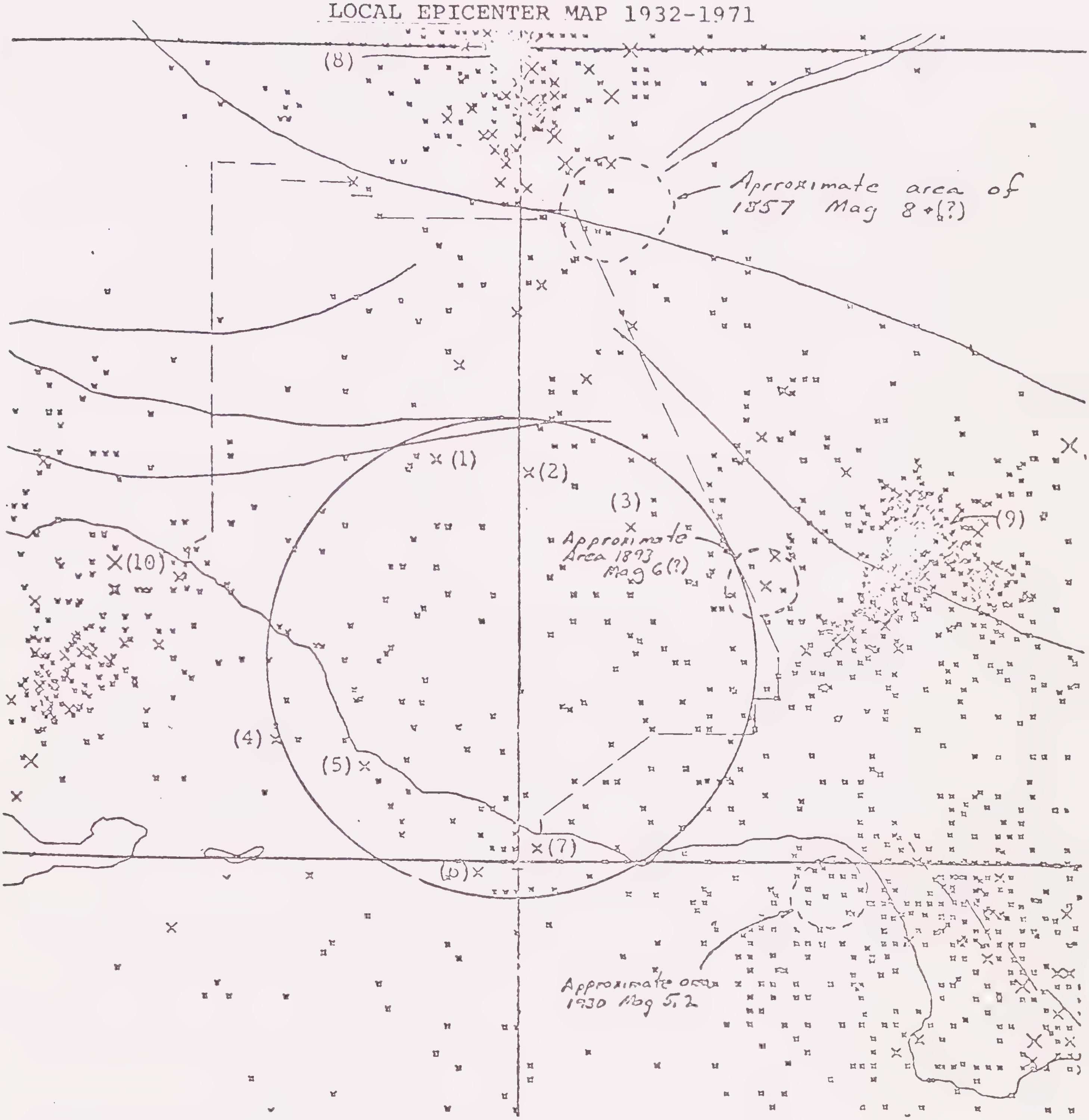
4 ≤ M < 5

5 ≤ M < 6

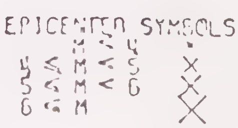
6 ≤ M

Illustration 7

LOCAL EPICENTER MAP 1932-1971



Epicenter	Date	Magnitude
(1)	11/17/54	4.4
(2)	9/ 3/42	4.5
(3)	6/ 1/46	4.1
(4)	8/22/50	4.2
(5)	3/18/57	4.7
(6)	5/29/55	4.1
(7)	4/16/48	4.7
(8)	7/21/52	7.7
(9)	2/ 9/71	6.4
(10)	7/ 1/41	5.9



DEFINITION OF THE HAZARD ZONE

The ground shaking hazard zones as indicated on Hazard Plate II (Southern Ventura County and Northern Ventura County) are based on the concept that ground shaking is partly determined by the thickness of the alluvium or unconsolidated material overlying relatively firm bedrock or consolidated earth material and the depth to the ground water table. The zones identified are as follows:

> Zone A. Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels at about 15 feet or less below ground surfaces. These areas could experience the greatest amplification of long period ground vibration. Therefore, buildings such as high rise structures which have long natural vibration periods could be more susceptible to damage in this zone.
>
> Zone B. (So. County only) Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels more than 15 feet below the gound surface. These areas could experience moderate amplification of long period ground vibration. Therefore, high rise structures which have long natural vibration periods could be more susceptible to damage in this zone but less susceptible than in Zone A.
>
> Zone B-C. (No. County only) Areas underlain by alluvium less than about 50 feet in thickness and with groundwater levels more than about 15 feet below ground surfaces. These areas could experience the greatest amplificaiton of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.
>
> Zone C. (So. County only) Areas underlain by broken bedrock adjacent to faults or where ground alluvium less than about 50 feet in thickness. These areas could experience the greatest amplification of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.
>
> Zone D. Areas underlain by soft sedimentary bedrock or Terrace Deposits with some soil cover (generally thicker on lower slopes). These areas may not experience as severe shaking as the other zones, but more than Zone E because of softer materials and relatively thin soil cover. Amplification of short period ground vibration could be slight to moderate. Therefore low rise structures of short natural vibration periods could be somewhat more susceptible to damage.

Zone E. Areas underlain by hard bedrock with little or no soil cover. These areas may not experience as severe shaking as the other zones because the thin or lack of unconsolidated cover (soil) or significant free groundwater will not allow amplification of shaking.

Man-made structures within a zone will respond differently depending upon their natural periods of vibration. Similarly, two structures with the same natural period will respond differently in different zones. Generally those structures which have a natural frequency close to the ground frequencies that receive the greatest amplification within the zone would sustain the greatest shaking.

The boundaries of the Ground Shaking Hazard Zones should be considered as only approximate. In addition, the estimated response of structures and amplification of certain ranges of ground vibration may vary greatly within a given zone during a given earthquake depending upon its origin, i.e., magnitude, location, distance and depth.

The ground responses estimated for each zone represent generalizations illustrative of the possible variation in the predominant ground response possible from one area to another resulting from perhaps a large earthquake generated along the nearest portion of the San Andreas Fault. The highly complex nature of the geology of Ventura County and the great number of faults along which earthquakes could occur does not allow accurate determination of the range of predominant ground responses which could occur within any one zone.

Present technology or "state-of-the-art" will, however, allow determination of the likely ground response within an individual site proposed for development during an anticipated earthquake, but only after detailed geologic, seismologic and soils engineering investigation of the site.

NATURE OF INFORMATION

The information used in delineating the Ground Shaking Hazard Zones on Hazard Plate I is regional in nature and is based upon available groundwater levels and the presence of alluvium as mapped (compiled) as part of the recently completed report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973) and the Los Angeles Sheet of the Geologic Map of California, both prepared by the State Division of Mines and Geology

and estimated depths of alluvium. The hazard zone locations, boundaries and estimated ground response are not sufficiently accurate on which to base design criteria for individual site development or even provide a basis for land use planning except in the broadest sense without more detailed investigation.

The technical information is based primarily upon statistical data and seismic reports which date back to only the late 1800's and recent experience and research by various govenmental agencies and universities. Much of the information utilized was from that developed and published since the San Fernando Earthquake of February, 1971.

The Ground Shaking Hazard Zones designated on Hazard Plate I are only approximations and of insufficient accuracy to base any building code requirements. In addition, the estimated ground shaking characteristics are general approximations and may vary greatly within a given zone during a given earthquake.

Recent communication with the State Division of Mines and Geology indicates that the Division believes that the "state-of-the-art" for predicting ground response to waves transmitted by earthquakes has not reached the point where regional maps delineating zones showing predictable intensity or type of shaking can be made with any degree of accuracy.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

Research and experience dealing with the nature and mechanism of earthquake ground shaking is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a state-wide basis, however, indirect benefit to Ventura County will ge gained through developed technology.

The State Division of Mines and Geology is currently investigating the extent of the hazard to Ventura County as part of the cooperative Geologic Hazards Investigation scheduled for completion by July of 1975.

Additional investigation is being conducted on a continuing basis by:

Private Geologic Consultants who provide original information during investigations for private developments.

Ventura County Department of Public Works which:

a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.

b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.

c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated areas and for the Cities of Camarillo, Simi Valley and Santa Paula.

Individual site investigation to provide detailed estimates of ground shaking sufficient for design purposes would include determination and analysis of the following information:

1. Depth and character of earth materials.
2. Presence and depth to groundwater.
3. Depth to and character of bedrock.
4. Evaluation of past earthquake records.
5. Estimate of the most likely earthquake to occur within the life of the proposed structure based upon existing earthquake records and evaluation of the potential activity of nearby as well as distant faults.
6. Evaluation of applicability of ground response records from other earthquakes and modification of them as necessary to suit the site in question or determination of ground response by computer methods.

WARNING

There is no way to prevent or predict to any degree of accuracy earthquakes or severity or kind of ground shaking during earthquakes at the present. Although it may be that developing technology will enable earthquakes to be predicted, in the not too distant future, the potential availability of such information may have undersirable side effects, such as drastic and sudden

effects on land values, insurance rates, business and the disruptive impacts caused by the possible large, rapid migrations of the populace out of affected areas.

ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

- City and County Departments of Planning, Public Works, and Building and Safety

- City Councils and the Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies through requirement of review of proposed land use and evaluation of investigation and engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to determine the need for any additional, more detailed studies and for formulating investigation and design requirements to avoid improper land use and inadequate construction. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include port districts and redevelopment agencies.

Alleviation of existing hazards can be effected by replacement or strengthening of structures which may not be designed to resist strong ground shaking or modification of land uses as hazardous structures are removed. Determination of whether structures are hazardous would require detailed geologic-seismic and soils engineering investigation of seismic and foundation conditions and structural engineering evaluation of the particular structure.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

During the initial study of seismic hazards in Ventura County in 1974, most of the City of Moorpark was included within the B & C ground shaking categories. That is, those which have deep alluvial deposits, but do not have high groundwater levels and those which have shallow alluvial deposits and do not have high groundwater levels. The hillside areas of the City are in the D category, moderate impact from short period ground vibrations. There is nothing to indicate, at the present time, that the original conditions have changed. However, the rising groundwater throughout the groundwater Moorpark Basin will change most of the category B areas to category A areas, probably within the next ten years if trends continue. The difference between the A and B classification is only one of severity in terms of ground shaking and affects only larger structures such as industrial buildings or high rise structures which are most susceptible to long wave ground vibration. The areas along the margins of the valley adjacent to the hills, as indicated on the County hazard plate, would be where smaller commercial industrial or residential structures would be affected by the short period

vibrations which affect small structures the most.

The hillside areas would be affected by a slight to moderate amplification of short period ground vibration which would affect single family residential structures, but is relatively unimportant in terms of a hazard.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Most of the main portion of the City extending from approximately Moorpark Road west down the valley is underlain by the deep alluvial deposits which would amplify long period ground vibrations, but only to a moderate degree. The City has been in a more favorable position than most of the cities in the County in terms of the ground shaking hazard, but this is coming to an end. As the water levels in the groundwater basin increase, the groundshaking and attendant liquefaction hazard increases as discussed in the liquefaction Section.

A comparison of Hazard Plate II with the map of present land uses within the City would indicate a number of commerical industrial, residential areas and vital facilities are affected by the long period vibrations of Zone B with varying degrees of severity for potential ground shaking. In general, the urbanized area of the City is located within the zone of greatest amplification of long period ground vibrations.

On the basis of present information, however, it cannot be concluded that any of the structures or facilities are unsafe. It is possible, however, that the investigation of many critical or vital structures may show that the degree of structure safety may be less than desireable.

PROBABILITY OF OCCURRENCE

Available geologic information indicates that the potential for strong ground shaking occurring over much of the County as a result of an earthquake along one of the major faults within the County, in the useful life of existing structures, is high when compared to other areas of the State.

Ventura County is considered subject to a higher than statewide hazard level from ground shaking because of the nearby presence of several large, potentially active fault systems. Exactly where, when and how strong the next earthquake will be cannot be determined.

SEVERITY OF THE HAZARD

The State Division of Mines and Geology in their publication entitled "Urban Geology" (1973, Bulletin 149) indicates that on a

statewide basis the potential hazard to structures from ground shaking is higher than any other hazard. The anticipated losses from ground shaking for the years 1970-2000 are estimated to be over twice that from landsliding and over 200 times that estimated for fault displacement.

In the event of a strong earthquake (6.0 - 7.5 magnitude) originating in the vicinity of the southern County area or a major earthquake (8.0+ magnitude) along the San Andreas Fault, damage to many existing structures could be severe and some loss of life could occur.

The present level of knowledge and state-of-the-art concerning ground shaking does not allow a complete determination of the factors affecting the type or severity of ground shaking that will or could affect areas within the City. The determining factors include location of the earthquake, direction of waves generated, type of predominant waves, magnitude, type of fault movement, density and depth of earth materials, etc.

The effects of the hazard can be reduced by prudent location and design of proposed important structures and vital facilities and determination of which such existing structures and facilities should be strengthened, replaced or modified in use.

NATURE OF INFORMATION

LIQUEFACTION

Safety Element
CITY OF MOORPARK

The conclusions provided by this study are based primarily upon historic experience as well as the considerable scientific research which has been undertaken since occurrence of the 1971 San Fernando earthquake.

The hazard boundaries as well as ground responses indicated on County Hazard Plate II are at best conjectural. The information is only illustrative of the wide range of ground shaking that can be anticipated over relatively short distances based upon the type and depth of earth materials and presence of groundwater. Other factors which must be evaluated in determination of potential ground response include density of earth material, location, magnitude and depth of the earthquake, type of bedrock and type of faulting causing the earthquake. Determination of these factors requires detailed investigation of an individual site, and are identifiable only within certain limits.

and lo, there was a great earthquake...
and every mountain and island were moved
out of their places.

Revelations, Chapter 6
Verses 12 & 14

GENERAL DISCUSSION

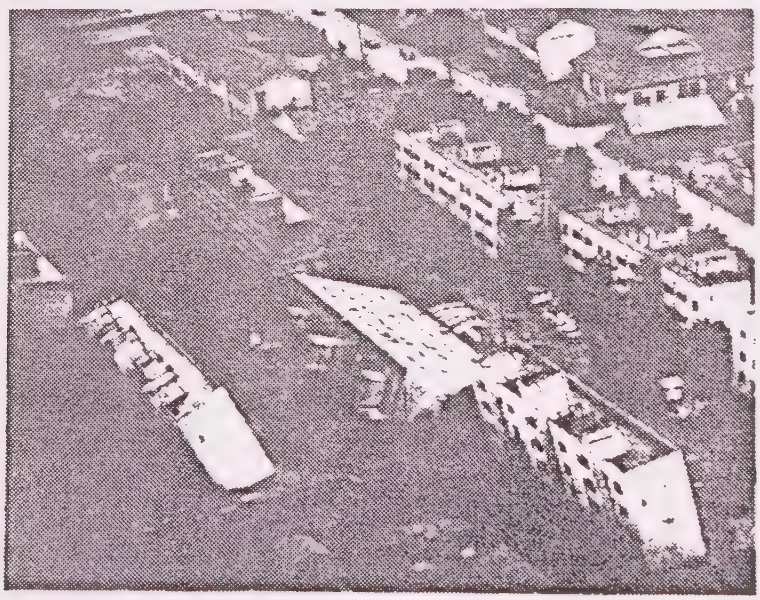
GENERAL DESCRIPTION

By far the greatest threat from an earthquake is the ground shaking that is produced and the resulting direct and indirect effects on manmade structures. In some earthquakes ground shaking results in ground failure, which can have catastrophic effects on structures. Ground failure is most often caused by liquefaction and can occur on relatively level ground.

Liquefaction can occur when loose cohesionless, uniform soils saturated with water are subjected to ground shaking of high enough intensity and long enough duration. Liquefaction is manifested either by the formation of sand boils and mudspouts at the ground surface and the seepage of water through ground cracks, or in some cases, by the development of quicksand-like conditions over substantial areas. When the quicksand-like conditions occur, buildings may sink substantially or tilt into the ground (see illustration 1 and lightweight buried facilities may float to the surface. (Seed, 1969) Other manifestations are landslides which can move hundreds of feet and lateral earth spreading of tens of feet.

Illustration 1

Tilting of apartment buildings, Niigata, Japan (1964)



A number of conditions are necessary to produce liquefaction. These include low density of the soil, uniformity of grain size, confining pressure, saturation of the soil materials with water, the intensity of the shaking and the duration of the shaking. In terms of density of soil, loose soil materials are most subject to liquefaction. Uniformity of grain size, such as a deposit of only sand, causes materials to be more susceptible to liquefaction than well graded materials. The deeper in a soil zone, which is susceptible to liquefaction, the higher the confining pressure will be and consequently, the potential for liquefaction is reduced. The soil must be saturated with water for any other conditions to apply.

Depending upon the confining pressure and the specific soil conditions, a certain intensity of shaking is required to trigger liquefaction. Intensity depends on the magnitude of the earthquake and the amplification of the ground shaking. Finally, the duration of the shaking is also important, as it takes a certain number of cycles of ground shaking for liquefaction to occur. The landslides of the 1964 Alaskan Earthquake did not occur until 90 seconds after the shaking started (Seed and Indriss, 1972). As compared to the 1971 San Fernando Valley Earthquake, where landslides were triggered after only 30 seconds of shaking.

Technically speaking, when a saturated sand is subjected to the necessary amount of ground shaking, it tends to compact and decrease in volume; if drainage cannot occur, the decrease in volume increases the pressure of the contained water. If the pressure reaches a point equal to the over-burden pressure, the sand loses strength completely, and develops into a liquefied state (Seed, 1969).

Liquefaction can occur at any level of a deposit but usually occurs within the first 40-50 feet. The potential for liquefaction exists wherever there are saturated loose sand deposits, especially if they are near the surface.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

There are two major kinds of liquefaction. The first is where surface or near-surface liquefaction of soils occurs. Structures whose foundations are within such a liquefaction zone lose support under part or all of their foundations, which causes them to tilt or settle into the ground surface. If a building is not designed to take this amount of stress, the entire building may collapse. A partially liquefied layer can also flow out from under the weight of the foundation with similar settling effects. As a general rule, for structures not designed against liquefaction, the larger the structure the greater its potential for settling through liquefaction during an earthquake. Thus, while differential settling may affect almost any structure, smaller buildings such as single family frame homes are not likely to suffer major damage except in situations where the water table is less than fifteen feet from the surface. Larger buildings not designed against liquefaction, however, can be severely affected at almost any level down to about forty to fifty feet below the surface, as loss of frictional support of deep pile foundations can occur. In addition, light sub-surface structures such as pipelines and storage tanks can float to the surface during the ground shaking, causing further damage and potentially widespread dislocation of services.

The second type of liquefaction occurs when the soil layer that liquefies is below the surface. As the soil compacts under the ground shaking of the earthquake, the hydrostatic pressure increases. This pressure is usually relieved by the flow of water and soil to the ground surface. If the flow is small and the areas localized, the effect on the surface is that of sand boils and mudspouts which can last for a number of hours after the earthquake. However, if the flow is large and general, it will induce a 'quick' or liquefied condition at the surface, with the same results as surface liquefaction. If the subsurface liquefaction occurs on a slope, the liquefied layer can act as a lubricated plane for the layer above it to respond to gravity and move downhill. The effect is even more pronounced if the water cannot escape vertically and is forced horizontally along a contact surface. This type of liquefaction is a common cause of earthquake-induced landslides. Structures built across the edges of the slide are torn apart in much the same manner as if they were located on a fault (See illustration 2,) a good example of this occurr

in the 1971 San Fernando earthquake where the Juvenile Hall slide was caused by liquefaction of a subsurface layer. An area of almost 163 acres moved down a 2.5% slope causing damage of over $30 million. Movement down a slope with such a low gradient had not previously been recorded, but such effects must be considered in future earthquakes.

The liquefaction also often causes settlement of the soil. In Niigata, Japan, after the 1964 earthquake, settlement of over 3 feet was common. In Alaska, the ground around one wellhead settled 4.5 feet.

SECONDARY EFFECTS

Liquefaction could destroy or disrupt much of the infrastructure (i.e., gas lines, water, sewer, roads, etc.) in an area. Pipelines could be broken either by being floated to the surface or by landslide displacement. Bridge abutments could suffer differential settlement, cutting off roads. The settlement of large areas of land could drop some areas below sea level and produce a new shoreline, or at least require reconstruction to re-establish continuity of roads, etc. (see subsidence hazard).

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hazard exists wherever there are certain soils, particularly loose sand soils, that are constantly or seasonally saturated with water. This might include most of the river valleys and the low lying plains areas that have poor drainage (Hazard Plate V). Since subsurface soil properties are not precisely known, it is necessary to assume that all alluvial areas having high groundwater may be subject to liquefaction during strong earthquake shaking.

Most of the Oxnard Plain and Pleasant Valley have these characteristics and therefore, must be considered to have a very high liquefaction potential. Virtually all of the low lying areas in the Ventura River drainage appear to have these characteristics as does most of the Santa Clara River. Simi Valley appears to have a high liquefaction potential in both the east and west basins and the latter has water wells that are freely flowing at the present time. Most of the remainder of the Calleguas Creek areas appear to have adequate drainage to avoid the hazard, except for the lower Arroyo Conejo.

The lower Arroyo Conejo may have an increasing problem because the discharge from the Thousand Oaks sewage treatment plant contributes to higher groundwater levels in the western Santa Rosa Valley area and along the Arroyo further to the west. Thousand Oaks may have problems in the low lying valley areas, including Hidden Valley, because of their alluvial nature.

Most of the beach areas of the County including the entire coastline from Point Mugu to and including the Ventura River delta are probably underlain by loose water-saturated sands and other alluvial deposits which could be subject to liquefaction during strong earthquake shaking. Low-angle landsliding or lateral spreading along the beach areas could occur as a result of liquefaction of these deposits. In addition, landsliding could occur within and adjacent to the submarine canyon areas (see Hazard Plate V).

HISTORY OF THE HAZARD

Liquefaction has not yet been a damaging hazard in Ventura County, but along with its attendant ground shaking, it is possibly the biggest seismic threat in the County.

Some experience from other areas will possibly provide an insight into the potential effects of liquefaction on Ventura County. The effects of liquefaction was well illustrated by the Niigata earthquake of 1964 (See illustration 8.1). The structural damage was severe and there were numerous other damaging effects such as sand eruptions, water flows, landslides and settling of the ground surface.

In the Alaskan earthquake of 1964, there were numerous bridge foundation settlings, but the most severe damage was from the Turnagain Landslide, which was caused by liquefaction (See Illustration 8.2). The most startling discovery of the 1971 San Fernando earthquake in regard to liquefaction was that major slides could occur on slopes with an inclination as low as 2.5%.

Locally, liquefaction occurred in Calleguas Creek, Mugu Lagoon and the lower Santa Clara River during the February 21, 1973, Point Mugu Earthquake. The effects were mainly the development of minor ephemeral features such as shallow cracks and sand boils, but as Morton and Campbell point out in their report (California Geol., Dec. 1973) if the "shaking had been more severe, such effects might well have been widespread and could have resulted in significant agricultural crop losses". Also, the effects on structures could have been significant also.

Illustration 2

Eastern Portion of Turnagain Slide

SOURCE: U.S. Army photograph

Illustration 3

Turnagain Heights, Anchorage

This photo well illustrates the spectacular slide damage caused by the March 27, 1964, earthquake to the roadway and homes in this suburban development.

Eyewitness reports of the effects of the 1857 Fort Tejon Earthquake (magnitude $\pm$ 8.0) on the San Andreas Fault suggest general liquefaction occurred along the Santa Clara River, along with other damage.

DEFINITION OF THE HAZARD ZONE

Since soil properties are not precisely known all alluvial deposits must be considered to be subject to liquefaction until investigation proves otherwise. Consequently, areas which are designated as within the high hazard zone are alluvial areas which have had water table levels within 15 feet of the ground surface at some time in the last fifty years or since well records have been kept. The moderate hazard is defined as including alluvial areas which have had water between 15 and 40 feet of the surface.

Large areas of the county have a surface layer of unconsolidated sand deeper than 40 feet and the entire county is susceptible to possibly severe earthquake shaking. Therefore, the primary variable factor for liquefaction in the County is the depth of the water table. The water level varies, but to be conservative, the highest level was selected. This is reasonable in urbanized areas where the water table is usually rising due to a number of factors including; curtailment of pumping; importation of increased amounts of water; reduced evaporation due to paving; heavy irrigation from watering of yards; percolation of sewage, etc.

The threat posed by this hazard varies depending upon the seasonal water level in some areas. The hazard zones designated assume that water levels are at their highest.

The significance of the water level being less than 15 feet from the surface is that in this range even small structures such as single family residences could be affected by liquefaction. This is the level at which the most severe liquefaction damage occurred in the 1964 Niigata, Japan earthquake. The 40-foot level corresponds to approximately the deepest level at which liquefaction most commonly can occur and is the level above which most building foundations are constructed, except for important structures.

NATURE OF THE INFORMATION

Data on the water surface level was taken from the extensive well records maintained by the Hydrology Section of the Ventura County Department of Public Works. These well records include up to 50 years of actual measurements at approximately one-month intervals.

Certain areas did not have usable well records. For these areas, either other special reports were used or actual field data was collected. One of the areas so field checked was Pleasant Valley. Alluvial areas are shown on Plate I of the State Division of Mines & Geology report entitled: Geology and Mineral Resources Study of Southern Ventura County (1973).

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATIVE

The Ventura County Department of Public Works, Public Works Departments and City Engineers of the various cities have primary responsibility for future investigations of the liquefaction hazard. The California Division of Mines and Geology, using information supplied by the Ventura County Planning Department did a fairly detailed analysis of the hazard as part of the Cooperative Hazard Study in 1975. The liquefaction hazard in the Moorpark area was updated in 1986 as part of the City's General Plan update. The California Department of Water Resources and the U.S. Geological Survey have ongoing projects to study groundwater and water table levels that affect liquefaction potential. Further research by Federal and State agencies should be undertaken to more precisely determine the location and magnitude of the hazard as well as possible methods to counteract it.

ALLEVIATION

There is little that can feasibly be done to reduce the regional hazard. Important or critical structures can utilize special designs to alleviate the affects of the hazard, except possibly an area subject to liquefaction induced landsliding. Whether or not land use controls are instituted by the Planning Commissions and City Councils or the Board of Supervisors, depends upon these entities' perception of the probability of the hazard occurring, the cost of restricting land uses and their concept of acceptable risk. Present subdivision grading and building ordinances require geologic and soils evaluation of hazards such as liquefaction to be considered in the design of land developments and construction of important or critical structures; as well as single family and all other homes where necessary.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

During the initial Seismic Safety Element preparation, detailed well log monitoring reports were used to determine water table levels throughout the County. In the City area, high groundwater table levels, within 15 feet of the surface, existed only along the Arroyo Simi west of Simi Valley to approximately Virginia Colony and were restricted to the immediate stream channel area. As part of this Element preparation, John Turner of the County

Flood Control District identified the increasing groundwater levels in Moorpark as a potential hazard to be investigated. The well records were updated from the County and new water level maps were prepared. The level has risen appreciably in the area down to Virginia Colony until it extends north of Highway 118 in some places. Further, the very deep water levels that existed within the main portion of the City, Little Simi Valley in 1974, have risen from over 100 feet to within 40 feet of the surface where there could be a potential hazard to large structures. The rate of increase has been approximately 3-4 feet a year throughout the City area. It appears that within the next 10 years, water tables will reach critical levels throughout the Little Simi Valley Basin area on both sides of the Arroyo Simi throughout the main portion of the City. Moorpark Safety Plate II shows the present water table level contours below ground level within the City area and further shows where the probable water table levels will be if the groundwater keeps rising at the present rate. The Tierra Rejada Valley to the south does not have the groundwater table problems that exist within the City itself. The rising groundwater levels in the City are caused by the filling and overflowing of the Simi groundwater basins into the Arroyo Simi and flowing downstream, filling the local alluvial basins and their perched water table levels. This is combined with the decrease in agricultural pumping as the area urbanizes, to increase the water table levels up to higher than historical levels within the basins.

LOCAL RESOURCES AFFECTED BY THE HAZARD

At the present time, the major core of the City as well as the new industrial parks are being developed in areas where they could potentially be affected by the liquefaction hazard both directly by liquefaction of the foundations and attendant differential settlement and possible low angle landsliding caused by lubrication of subsurface material on gentle slopes. The soil materials throughout the area are generally sandy in nature which are susceptible to liquefaction in case of intense ground shaking due to an earthquake. Any new major structures constructed within the City should recognize the potential liquefaction factor and the City should consider whether further studies and perhaps special foundation treatments are necessary for larger structures within the hazard areas. Heavy liquefaction over a general area would damage or destroy most structures and could cause a severe economic loss. It even could cause loss of life through some structure collapse, although this is a rare condition. The information used to define the zones on Moorpark Hazard Plate II were the best available at the time, but does not allow precise delineation of hazard areas to be used for building purposes. Also, the boundary lines represent a transition zone which flutuates seasonally and with changes in water supply. Therefore, those facilities mentioned are not necessarily the only ones that could be affected by hazard. These however, should be studied first when alleviation of the hazard is

considered because of the higher probability of them being affected. Also, a major change in the use of water or of the overflowing of the groundwater basins from Simi Valley could preclude the complete filling of the Little Simi Valley basin and keep the hazard from getting worse in the future. A severe liquefaction threat will exist in the entire hazard zone within the next 10 years unless conditions change. Liquefaction has occurred in similar areas in the County and can be expected to occur again whenever an earthquake of sufficient intensity occurs. According to many experts, a major earthquake on the San Andreas Fault in Southern California is possible within the next 50 years and other smaller earthquakes are quite likely. Any intense ground shaking can trigger liquefaction in affected areas.

SEVERITY OF THE HAZARD

The most severe hazard exists in areas of loose sandy alluvium which also have high groundwater levels, but lessens progressively in areas of more compacted soil and where water levels are lower. The severity of the effects depends upon the soil properties, the intensity and duration of the shaking and the type of ground failure. If general surface liquefaction were to occur, most structures in the hazard zone would be affected to a greater or lesser degree.

ESOURCES AFFECTED

The area from Simi Valley to Virginia Colony along both sides of the Arroyo Simi is presently affected by the hazard and the potential exists for a major portion of the City to be affected within the next few years as conditions continue to change. However, the greatest threat will be the area closest to the Arroyo and the threat will decrease with distance from it. Large industrial and commercial facilities or major residential structures would probably substain the major property damage in case of general liquefaction.

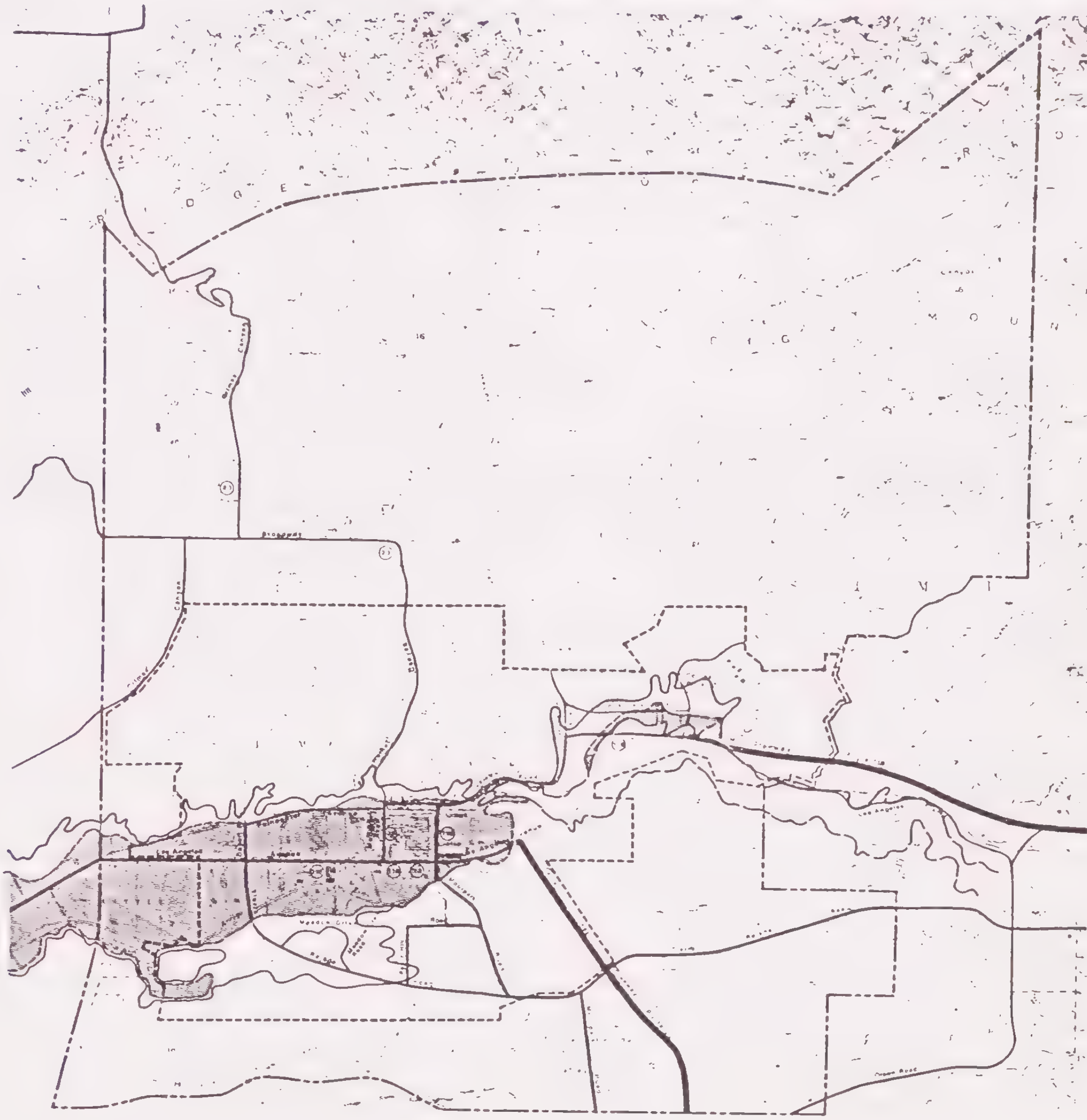
NATURE OF INFORMATION

The water table levels in the alluvial areas were arrived at by taking the highest figure measured by the extensive records of the hydrology section of the County Department of Public Works originally in 1974 and again updated in early 1986. The boundaries of the hazard zones are only approximations and are not accurate enough upon which to base any building code requirements. In addition, the estimated affects of liquefaction can vary greatly within a given zone during a given earthquake. Any specific conclusions should be reached on the basis of detailed site by site soils and geologic studies and be determined upon finding of sandy soils within the area along with

high ground water levels. All new structures should have engineering soil analysis including testing for the water table levels at the site and the type of soil materials. A competent geologist should determine whether or not the site could be susceptible to liquefaction in high ground shaking events.

OTHER FINDINGS

Special attention should be given to the existing high liquefaction potential in the evaluating the adequacy of existing important or critical facilities in the high hazard areas. Since that threat may be quite severe, especially to larger buildings and other critical facilities and structures, proposed developments must presently meet the requirements of numerous ordinances enforced by the County Department of Building and Safety, under contract with the City, and by the City Engineer as well as the City Planning Department all of which require consideration of various conditions including potential liquefaction.



LEGEND

Existing Water Table Level Within 15' of Surface

Projected Level Within 15' of Surface

Water Table Level Within 40' of Surface

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE II

Liquefaction

CITY OF MOORPARK

JSA Joel Silverman & Associates

LANDSLIDE/MUDSLIDE

Safety Element
CITY OF MOORPARK

JSA

Against the wreckful siege of battering days...rocks impregnable are not so stout.

Shakespeare

GENERAL DISCUSSION

GENERAL DESCRIPTION

All hills, mountains and other highlands are being worn down by various natural processes. The most spectacular of these is the landslide, along with the other related types of ground failure. These processes are referred to geologically as "mass wasting", defined as: "the en masse downslope movement of rock debris" (Physical Geology, p. 134) . There are numerous causes for mass wasting, including erosion, water, broken or weak bedrock, earthquakes, and engineering defects.

Stream erosion can undercut slopes thereby removing support and causing failure of slopes by landsliding.

Saturation of soil or bedrock on hillsides can reduce the strength of these materials under certain conditions to a point where downhill sliding can occur in response to gravity. Rainfall can also saturate and erode vast quantities of loose soil, especially after large fires denude slopes, washing it down slope as earth or mud flows.

Earthquakes can directly shake loose material to fall or slide downhill; it can also cause liquefaction of sub-surface materials, which also can lead to slides (see Liquefaction Hazard).

Finally, man-made cuts or excavations can undercut unstable slopes, thus causing landslides. In practice, most landslides are caused by a combination of two or more of these factors, and come in a number of forms.

First is the rockfall, which is simply the movement of all or part of a mass downslope without seriously disturbing the surface it moves over. This is most common on coastal or other types of bluffs in this area (Illustration 5.1).

More complicated are slides, which are a type of ground failure that affects both the soil and the subsoil surface. In a relatively homogeneous material the normal type of slide is a slump (Illustration 5.2). The plane of failure is usually curved and the two (the downhill end) flows out from under the surface as it rotates backwards as a unit. In a stratified, layered rock, the slide tends to be a block glide in which large masses of material move down an inclined surface maintaining their uniformity (Illustration 5.3). Both these types of slides can continue moving downslope after their

Illustration 5.1
Example of a Rockfall

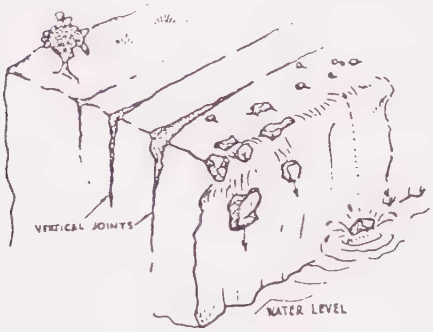


Illustration 5.2
Slump in relatively uniform material.

Note curved slide surface.

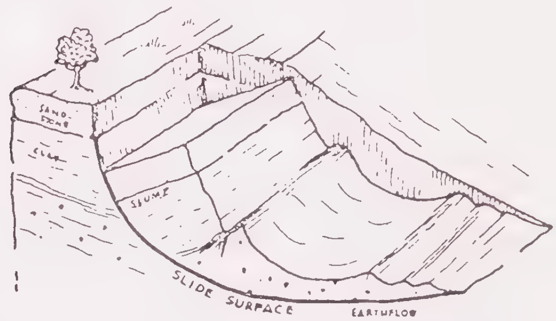


Illustration 5.3
Block-Glide in layered rocks inclined downslope.

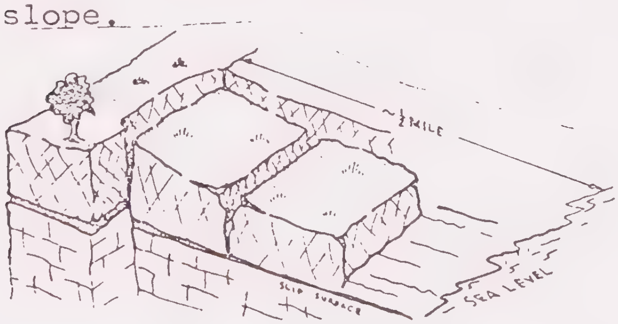
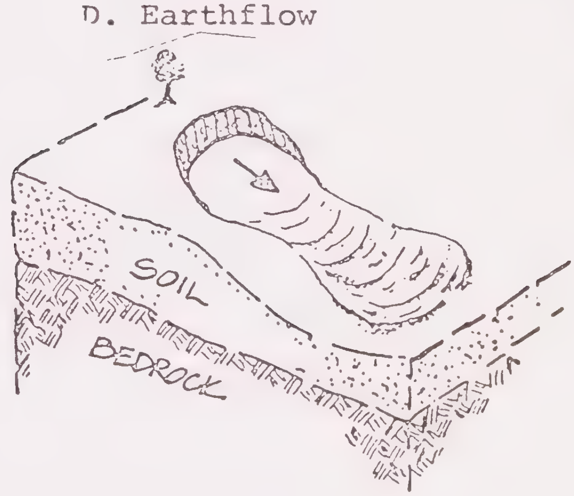


Illustration 5.4
D. Earthflow



SOURCE: Coastal Landslides in Southern California, and Ventura County Public Works.

initial failure and be broken up by the down slope spreading movement. These can continue far beyond the area in which they began and, if the movement is rapid, can move up onto the opposite side of a narrow valley.

Fourth and last, a flow is a landslide in basically unconsolidated material (Illustration 5.4). Most flows consist of saturated or nearly saturated material that undergoes viscous flow, although some types of flows are dry. Their movement is characterized by plasticity, which permits them to spread outward over wide areas and to move greater distance than other types of landslides. They often involve greater masses of material and continue downhill far beyond the base of the slope from which they originated. Many of history's most destructive landslides have been flows. Mudflows are a type of flow that are particularly prevalent after brush fires. Massively destructive mudslides hit Big Sur in 1972 after a brush fire, as they did in Glendora in 1968.

The speed with which landslides occur can vary considerably from rapid downfalls to virtually imperceptable movements downslope under the pull of gravity. Soil creep is a very slow type of earthflow movement. It occurs mainly in soils containing clay.

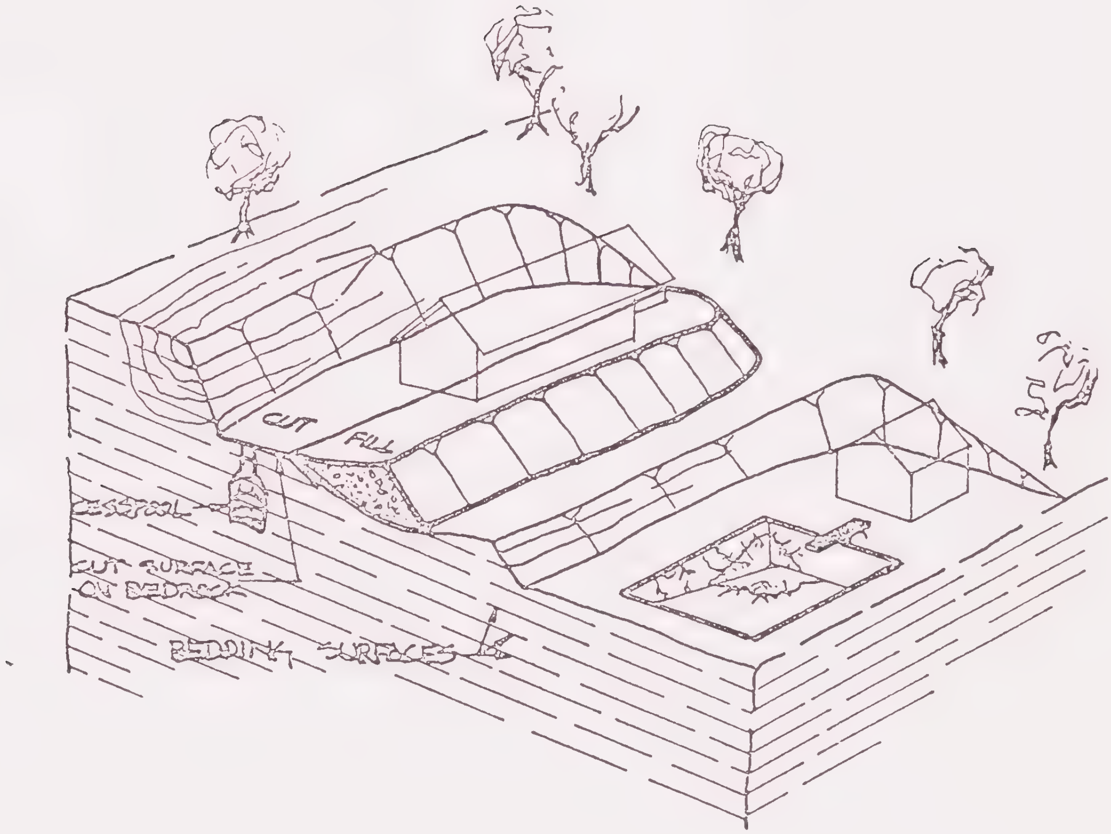
In general, most landslides within the county are shallow, ranging up to perhaps 100 feet in depth and limited in extent, generally less than 100 acres. Most are not presently in motion (active) but that moved downslope to positions of stability. Generally, stability is achieved within several years after the initial failure under natural conditions. However, the margin of stability of most landslides is small and inadequate to safely place structures on their surfaces.

Many of the existing landslides can be reactivated and downslope movement renewed after exceptionally heavy rainfall periods or as a result of earthquake shaking. Most landslides are over 100 years old and can exist for thousands of years until all of the landslide material is removed from the hillside by erosion.

Generally, the renewed movement of old landslides is slow, perhaps only a few inches per day. However, the formation of a new landslide can be rapid with initial, often quite sudden movements of hundreds of feet within a few hours.

Hundreds of landslides in Southern California are traceable to the general bedrock situation shown in Illustration 5.5. As long as the original natural slope remained ungraded it was stable because bedding surfaces

Illustration 5.5



DEVELOPMENT OF MAN-MADE BEDROCK LANDSLIDES (modified from R.H. Jahns). Hundreds of landslides in southern California are traceable to this general situation. This problem, as much as any other, has led to the adoption of grading ordinances. A naturally stable "dip-slope" has been made unstable by removing the support from bedding planes which resemble the surfaces between a tilted deck of cards. The cracking shown is one of the early signs that a landslide is imminent. Irrigation and sewage effluent contribute to slippage along the bedding.

were essentially parallel to the ground surface and were supported at the lower end. Once the slopes were cut, though, support was removed from the bedding surfaces.

The fill in the upper residential lot of Illustration 5.5 is uncontrolled and therefore is probably poorly compacted. In this state it can settle, erode and slough without sliding en masse. Settlement can crack the foundations and walls, because the portion of the house on bedrock will not settle as much as the portion on fill.

A cut-slope in which support has been removed can fail immediately upon being excavated; or it can continue to stand for a number of years. They are the principal slopes that give way one by one during succeeding wet seasons; their ultimate failure is inevitable. The cracking illustrated in Illustration 5.5 is one of the early signs that a landslide is eminent. As the cracks widen, they serve as channelways for surface runoff which facilitates mass movement.

The best evidence that the fill was not controlled during placement is that the soil zone was not removed by proper benching. If the soil is "adobe-like" the problem is compounded. The fill prism can skid as a unit along the top of the buried soil zone; or if the fill is bonded to the soil it can fail by flowage and creep of the weak adobe zone.

Man-made slides may occur during grading operations or after grading operations in hillside development. Those that occur during grading operations are generally not as hazardous nor as expensive to repair as slides that occur after development. Slides that occur after grading are an indication that the problem was not detected during grading, that sufficient corrective and preventive measures were not taken, or that stable conditions were modified after grading (Man-Made Landslides, F. B. Leighton, 1966).

GENERAL EFFECTS OF THE HAZARD

PRIMARY

Slope instability that results in landslides has caused substantial damage to the works of man in the Southern California area since the 1950's, when significant amounts of urban development first spread to the hillside areas within the County of Los Angeles. As a result of the heavy rains of 1952 there was approximately 7.5 million dollars of damage in the City of Los Angeles alone, due to erosion, deposition and landsliding. Strong hillside grading and building codes were established within Los Angeles County to prevent such future losses.

Geologic conditions similar to those within Los Angeles County also exist within the hillside areas of Ventura County. Future landsliding within Ventura County could also affect developed areas unless landslide hazard areas are recognized and appropriate land uses are designated.

In general, landsliding and the differential subsidence of the surface of landslides as well as the lateral forces exerted by most landslides can destroy most engineering structures. Most structures cannot be economically designed to withstand the forces of landsliding. Mass grading techniques have proven to be the most effective means of stabilizing landslides and unstable hillsides. This grading technique basically involves leveling of hilltops or ridges and filling in of the valleys in between, resulting in a general reduction of the height and inclination of slopes within the area.

Primary effects of landsliding can include:

1. Abrupt depression and lateral displacement of hillside surfaces over distances of up to several hundreds of feet.

2. Disruption of surface drainage.

3. Blockage of channels and roadways.

4. Displacement and breakage of utility lines (pipe and power).

5. Displacement and destruction of any improvements such as roadways, buildings, oil and water wells, etc.

SECONDARY

Secondary effects of landslides can include temporary impact on society such as displaced persons and families, and possible loss of life, damage of nearby property, etc. In addition, damage suits can be initiated against original developers of the property affected by landsliding, as well as the present owners and the government agency which may have reviewed the development, approved the plans and issued the grading and/or building permits.

Other effects could include:

1. Blockage of transportation routes.
2. Disruption of utility services.
3. Blockage of drainage.
4. Loss of usable land area, etc.

GENERAL INVENTORY OF THE HAZARD

LOCATION AND HISTORY

Southern Ventura County

The widespread landsliding and slope instability throughout much of southern Ventura County can be related to a great degree to the intensity of past faulting and folding of strata and to the clay content of certain sedimentary formations, as well as to subsurface moisture content. In general, the highest propensity for landsliding is found along the more prominent fault zones, anticlinal folds and in areas of the younger geologic formations. It is also apparent that the combination of these three factors has resulted in relatively intense areas of landsliding such as along the Rincon and hillsides south of the Santa Clara River.

Landslides and potentially unstable slopes are especially common in hillside areas underlain by sedimentary becrock of the Pico, Santa Barbara, Monterey/Modelo and Rincon Formations. These formations are generally uncemented (soft) and contain abundant silt and clay strata.

Many landslides are also associated with steep slopes which have been undercut by erosion (such as the several landslides along the easterly side of Big Sycamore Canyon northeast of Point Mugu) and downslope inclination of bedding planes (such as in the Ventura Anticline area). The presence of subsurface water is also a contributing factor to slope instability in the great majority of landslide occurrences.

Landslides and slope instability are widespread throughout the hillside areas. In general, most existing landslides are within the Existing Landslide Areas shown on Hazard Plate IV; most are not of recent origin, having occurred over 100 years ago, and most are not actively moving. However, they are subject to potential renewal movement if triggered by poorly planned grading, earthquakes, or if the ground moisture is increased. The areas of landsliding are, in general, confined to the areas of weak or clay bedrock and adverse geologic structure (such as bedding planes dipping in downslope directions).

Northern Ventura County

Landsliding is not believed to be of such widespread occurrence in the northern county area as to present any significant regional hazard. However, the region is extremely mountainous with steep slopes and local relief in most areas ranging from 200 to several hundred feet. Faulting and severe folding and tilting of bedrock strata is common, as are steep slopes. Another widespread condition which has contributed to formation of the present physiography and which affects the stability of hillsides is the general aggressive downcutting of stream channels.

The general, relative competence of the older bedrock throughout the region, in spite of the rugged physiography, has been the prime factor resisting the incidence of more widespread landsliding. However, many hillsides and existing landslide features are only marginally stable and only slight change in existing environmental conditions, such as would result from grading or irrigation, could trigger massive landsliding. In other words, the stability of many slopes is critically fragile and would, upon geologic investigation, show to be inadequately stable for most types of development.

DEFINITION OF THE HAZARD ZONE

Hazards Plate IV is a composite map showing landslide hazards within the southern county area. The Existing Landslide Areas designation includes area of major landslide features. The High Landslide/Mudslide Hazard zones indicate areas of marginal hillside stability which could be subject to major landslide occurrence. In general, the aforementioned categories are confined to areas containing ground surface slopes of 15% or more. Intermediate Hazard Zones are those

that could be subject to less severe landslides, but which have a definite risk slope, generally 10-15%. The Little or No Hazard Zone indicates areas which slope at less than 10% and not generally affected by landsliding. Active Beach Erosion is indicated for those areas which have, historically, been subject to severe wave erosion, which is considered a form of slope instability. Beach erosion per se, however, will be treated as a separate study within this Seismic/ Safety Element. (Landslide/Mudslide Hazard Southern Ventura County.)

The Hazard Zone boundaries were primarily determined based on information provided by two recent studies of landslide conditions in southern Ventura County (conducted by the State Division of Mines and Geology for the Federal Department of Housing and Urban Development (HUD) and for the County of Ventura under a cooperative agreement). The product of the latter study was the report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973), Preliminary Report 14.

NATURE OF INFORMATION

The potential landslide areas within the county were determined mainly by aerial photographic interpretation. The information is considered good, and fairly accurate. Knowledge of many locales, especially within or adjacent to areas of urban development was gained through experience in the particular area and field checking of some areas.

The current cooperative GEOLOGIC HAZARDS INVESTIGATION being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information on landslide hazards in regard to: (1) those portions of the north half of the county in which development could possibly take place and (2) areas of the southern half of the county which could be susceptible to low-angle or lateral spreading during earthquake shaking. Except for the information necessary under Item 2 above, the present information is the best form available and is considered adequate for general planning purposes. It will, however, need to be supplemented with more detailed mapping or studies for any specific proposed development.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The State Division of Mines and Geology is currently investigating geologic conditions as part of the cooperative Geologic Hazards Investigation, in those portions of the county in which development could possibly take place. The study will be completed in 1975 and will consider landslide hazards in portions of the north half, as well as the potential hazard of landsliding resulting from liquefaction of water saturated sediments during earthquake shaking in portions of the south half of the county.

Additional investigation is being conducted on a continuing basis by:

1. Private Geologic Consultants who provide original informatin during investigations for private developments.

2. Ventura County Department of Public Works which:

    a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.

    b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.

    c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.

WARNING

The potential for landsliding can be detected with relative certainty before any structures or facilities are placed in jeopardy. However, the problem is more difficult to handle in those hillside areas where development has already occurred in possibly dangerous

locations. In cases where structures have been constructed, regional studies can, in many places, delineate potential problem areas before damaging movement occurs. These studies can be conducted by local agencies and/or by cooperation between the property owners affected.

Presently, little is known of the potential for low-angle landsliding resulting from liquefaction of sediments during earthquake shaking or of areas in which this hazard exists. As previously indicated, this hazard is being evaluated under the Cooperative Geologic Hazards Investigation being conducted by the State Division of Mines and Geology.

ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

> City and County Departments of Planning, Public Works, and Building and Safety
>
> City Councils and the Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies by requiring the review of land use proposals and the evaluation of engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard can be affected, in part, through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to avoid improper land use. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include Port Districts and redevelopment agencies.

Present County Subdivision, Grading and Building Ordinances which are considered as strong or stronger than any in the Southern California, are adequate to insure that areas of landsliding or hillside areas

are adequately investigated and that any development incorporates appropriate design provisions to prevent landsliding. The Departments of Public Works and Building and Safety of both the County and Cities have the responsibility of adequately enforcing these or equivalent ordinances.

LOCAL DISCUSSION

LANDSLIDE/MUDSLIDE HAZARD

LOCAL INVENTORY OF THE HAZARD

Almost all hillside areas have some potential for landsliding and virtually all of them have a potential for mudsliding, especially after torrential rains or after fires. Most existing landslides have resulted from natural processes or erosion, soft bedrock, high levels of ground moisture, steep topography, geologic structure and/or earthquakes. Many were formed prior to historic times. Since the advent of modern grading equipment and the continuing development in the valleys and plain areas, hillside and coastal areas in Southern California have come under increasing pressure for urban development. As a result, man's activities involving cutting, filling, drainage, diversions, irrigation, use of onsite sewage disposal systems and stripping of vegetation from slopes have also become major factors in the formation of new landslides and in the reactivation of previously stable ones have also contributed to an increased mudslide hazard in newly escavated areas.

There are basically three existing landslide areas which have critical landslide morphology within the City of Moorpark:

The first is the north facing slopes of the Los Posas Hills west of Moorpark Homeacres which is in the area of interest

of the City, but outside of the present City limits.

The second, a much more serious area in terms of potential of urban development is that area of north and west facing slopes generally westerly of Walnut Canyon to the slopes just beyond Grimes Canyon Road. All of those north and west facing slopes should be considered to have a critical landslide/mudslide hazard potential and should be subjected to detailed geologic investigations prior to urban development. There are three large existing landslides within that area.

The third area is the hillside areas north of Tierra Rejada Road, but south of the Arroyo Simi, located east of the 123 freeway. This area has a number of existing landslides and also some areas of questionable landslide morphology.

These three areas should be considered high critical landslide hazard areas and should be subjected to detailed geologic investigations before allowing any development.

Moderate landslide/mudslide hazard exists in all hillside areas having a slope of more than 15%. The existing landslides and the high landslide hazard areas are indicated on Moorpark Safety Element Plate IV.

RESOURCES AFFECTED BY THE HAZARD

At this time, there is no existing urban development being threatened by the high or critical landslide hazards within the City's area of interest. The area between Walnut and Grimes Canyon which is presently being proposed for urban development and detailed geologic investigations will be necessary to alleivate any hazards that are identified.

FINDINGS

PROBABILITY OF OCCURRENCE

Landsliding can be considered a hazard in any hillside area and the hilly and mountainous areas of Moorpark are no exception. However, experience gained from intensive development and urbanization of many hillside areas in other regions of Southern California, should provide ample warning of the destruction that can and will occur from landsliding. Most destructive landslides have resulted from the indiscriminative development of sloping ground or the creation of cut and/or fill slopes in areas of unstable or inadequately stable geologic conditions. Most of the failure could have been prevented by recognition of the potentially unstable conditions by adequate investigation and incorporation of design safeguards prior to grading or

construction. The hazard of landslides, however, is not always confined to areas commonly considered hilly or mountainous. Under certain soil and ground moisture conditions, landsliding can occur in areas of nearly level ground. This was clearly demonstrated by the landsliding triggered during the San Fernando earthquake of 1971 which resulted in destructive lateral ground movement over large areas with regional slopes as little as 1 1/2 %. This was usually caused by liquefaction of the subsurface beds and subsequent movement of the surface. Conditions which could result in similar lateral spreading with low angle landsliding probably will exist within the City of Moorpark as the water level rises within the main areas of the City. (See liquefaction Hazard Section.)

SEVERITY OF THE HAZARD

The hazard from landsliding is considered to be critical within the extreme hazard areas. However, within the remainder of the City area, the hazard can be mitigated by normal review as presently being carried out by the City Engineer. Many of the destructive landslides that have occurred within the County, occurred in developments which were completed prior to present day grading and building codes. The level of hazard cannot readily be determined without detailed investigation of individual sites. This is considered to be the responsibility of the individual property owner with a review by the City Engineer.

RESOURCES AFFECTED

At the present time, most of the severe landslide areas are in agricultural use and until developed in urban type developments, the hazard affects only resources such as public roads or public utilizes that might traverse the landslide areas.

NATURE OF THE INFORMATION

The present information includes two detailed studies of landslides within the area and is considered quite good for the purpose of the general recognition of the hazard. However, any detailed site by site mitigation must be in response to detailed geologic investigation reviewed by the City Engineer.

OTHER FINDINGS

Existing landslides should be recognized and in general, their surfaces and immediate adjacent areas should not be developed. However, if explored in detail, it may be feasible to stabilize some of these features by buttressing, etc. or by excavating the entire slide area and thereby utilize the site for some appropriate development.

Land development of hillside areas could, of course, result in formation of new landslides if the grading or development design in hillside areas does not continue to take into consideration potentially adverse conditions which may exist in areas presently unaffected by landsliding. Many of the natural slopes are underlain by bedded sedimentary rocks that are inclined in down slope directions. The slopes in these cases are marginally stable and prone to failure along bedding planes. Uncontrolled grading or introduction to irrigation or onsite sewage disposal in areas underlain by ancient landslides could trigger renewed movement.

Extensive grading of the hillside areas in the City, as would be necessary for some high density development, is considered practical only by gross leveling of large areas by daylighting ridges, filling valleys and minimizing slope heights and inclinations to avoid large scars.

Most areas of landslides and adjacent marginally stable slopes will not be economically feasible to develop because of the massive grading necessary to affect stability. Landslide areas, or areas having the high propensity for landsliding, should not be considered as developable unless mass grading techniques involving filling of canyons and gross leveling of hillsides is anticipated. Only the smaller landslides can generally be stablized to allow development of their surfaces. Stablization

of large slides is generally too expensive to be feasible in most cases.

In general, high density subdivision development of hillside areas within this portion of the County is considered practical only by gross leveling of hillsides and filling of valleys thereby eliminating both high and steep natural slopes as well as the need for higher steep graded slopes. Presently, however, this will only be feasible in the lower hillside areas. Most areas of high relief and/or landsliding will not be economically feasible to develop because of the massive grading necessary to affect stability. Development of modern subdivision and grading ordinances such as existing presently in the City and other land development policies and building codes over the past several years has progressively resulted in greater public safety. The requirements are considered equivalent to or exceed those of most other areas of California. The present requirements are considered adequate to insure that areas of landsliding or areas prone to landsliding are not indiscriminately developed and that adequate measures are incorporated in grading and building design to insure that landsliding will not occur.

Little is known of the potential of landsliding or lateral ground movement resulting from liquefaction within the City. If the water table levels rise as predicted, some areas may have conditions conducive to this type of hazard. These areas would include most of the valley bottom areas adjacent to the Arroyo

Simi from the Simi Valley city limits west to beyond Moorpark Homeacres. If the water tables rises as predicted, the City Engineer should examine what policy should be instituted to mitigate against low angle lateral landsliding induced by liquefaction as well as a liquefaction hazard in general.

LEGEND

Existing Landslide Area

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

JSA Joel Silverman & Associates

North 0 2000 4000 FEET

MOORPARK SAFETY PLATE III

Landslide

CITY OF MOORPARK

DAM INUNDATION

Safety Element
CITY OF MOORPARK

JSA

Whom unmerciful disaster followed fast and followed faster.

Edgar Allan Poe

The Raven

GENERAL DISCUSSION

GENERAL DESCRIPTION

Potential dam failures affect the safety of many communities. Inundation maps for all major dams were prepared by dam operators, pursuant to Section 8589.5 of the Government Code of California. These maps are supposed to become a mandatory consideration in the Safety Elements after approval by the State Office of Emergency Services. A number of major dams affect drainage basins in the County. Lake Casitas is the largest dam in the County and is controlled by the Federal Bureau of Reclamation. Castasic and Pyramid Dams in Los Angeles County, but upstream in the Santa Clara River drainage system, are operated by the California Department of Water Resources as part of the California Water Project. Bouquet Canyon Reservior replaces the previous Saint Francis Dam and is the key storage reservior in the Los Angeles Aqueduct and is operated by the City of Los Angeles and Department of Water and Power. Lake Piru, also on the Santa Clara River, is operated by the United Water Conservation District. Lake Bard, the only major dam within the Calleguas Creek system is a key storage reservior on the Metropolitan water system and is operated by the Calleguas Municipal Water District. These constitute the major dams which present a threat of dam inundation in the County.

GENERAL AFFECTS

Complete failure of a modern dam is a very remote possibility. However, such failures have occurred in the past and their results are catastrophic.

PRIMARY AFFECTS

The primary affect of a dam failure is extreme flooding of large magnitude and with very little warning. The flooding caused by failure of a majór dam and the rapid discharge of the reservior impounded behind it causes inundation on a scale much larger than even the largest natural flood, but within a fairly localized area of that particular watershed downstream from the dam. The secondary affects of dam inundation include the destruction of infrastructure including: roads, pipelines and other municpal utilities as well as structures. Flodding also has a severe adverse impact on agriculture. It is hard to imagine anything other than a devastatingly massive earthquake which has more destructive potential than dam inundation within the affected watershed.

GENERAL INVENTORY

Major dams affect the Ventura River and Santa Clara River drainage systems. Only one dam, Lake Bard, affects the Calleguas drainage.

HISTORY

At two minutes before midnight on March 3, 1928, the Saint Francis Dam in San Franciscito Canyon, upstream in the Santa Clara River watershed located within Los Angeles County, failed suddenly and catastrophically. This dam, a thin and concrete structure, which had been completely filled for the first time the day before, was the key storage reservior for the Los Angeles Aqueduct. It was constructed and operated by the Los Angeles Department of Water and Power. The failure of this dam initially sent a 75 foot high wall of water proceeding downstream at a speed of 25 - 40 miles per hour, devastating the entire Santa Clara River watershed downstream to the ocean, including the communites of Saugus, Castaic Junction, Fillmore, Santa Paula, Ventura and Oxnard. It destroyed all major bridges over the river on its way to the ocean. This was the second largest disaster in the State's history in terms of lives lost, with an estimated 450 people killed. However, many of them were farm workers and an actual count was never completely determined. No report on this disaster was ever produced either by the Department of Water and Power of the City of Los Angeles or by

the State of California. However, the destruction was wide spread and devastating and can still be remembered by people who lived through it in the Santa Clara River Valley. More recently, other dam failures in and out of the United States have made the news. The only other major dam failure in Ventura County was relatively minor when the Sinaloa Dam failed in Simi Valley and the flooding was rather localized.

This section was not included within the Seismic Safety Elements when they were originally prepared in 1974, due to the lack of availability of dam inundation maps for the three largest dams affecting the County.

NATURE OF THE INFORMATION

Dam inundation maps, including the area that would be inundated due to catastrophic failure of each of the dams, have been prepared by the dam operators and have been made available to the County and the cities. However, since the material has been prepared by the private operators of the dams and the information represents the worst case example. Since there is a potential for misuse of the information, the County and most of the cities in the County have decided not to publish dam inundation maps, but have made them available to public service agencies for evacuation planning.

It should be pointed out that given modern construction technology, there is very little potential for failure of any kind from a modern dam. They are one of the most carefully engineered structures prepared by man. Also, the dam inundation maps that are prepared show only a worst case failure; a total and fairly rapid failure of the dam. For a thin arch cement dam, that would be a failure virtually instanteously and for an earth filled dam would be failure of the dam within an hour. Any failure of any kind is extremely remote and catastrophic failure even more remote. The dam inundation maps are maintained for use by law enforcement and other public disaster planning agencies for preparation of evacuation reports only and are not therefore, included within most Seismic Safety or Safety Elements.

GENERAL MANAGEMENT RESPONSIBILITY INVESTIGATION

Dam inundation maps are prepared by the dam operators and are maintained by the public service agencies within each of jurisdictions.

REGULATION

Dam inundation maps are prepared under the requirements of Government Code Section 8589-5 and dam inundation map preparation

is overseen by the Division of Dam Safety of the State Department of Conservation.

ALLEVIATION

If a catatrophic failure occurred, there would be no way to alleviate the hazard, except to evacuate persons and property as much as possible from the path of the flood. However, the chance of a dam failure is considered very remote.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Lake Bard, if it were to fail, would inundate most of the City of Moopark. Dam inundation maps have been prepared for the area affected.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Most of the structures located within the Valley Flood Plain of the Arroyo Simi would inundated by a failure from Lake Bard.

LOCAL MANAGEMENT RESPONSIBILITY

The County Sheriff Department and the County Department of Disaster Services maintain evacuation maps, should it become necessary to evacuate the area from any eminent failure of Lake Bard. The Calleguas Mutual Water District would notify the local law enforcement agencies of the City, County and the State Office of Disaster Services and the Office of Dam Safety if they felt any possibility existed for the failure of the dam impounding Lake Bard.

FINDINGS

PROBABILITY OF OCCURRENCE

Extremely remote. Even under severe earthquake shaking, Lake Bard, which is a modern engineered earth fill dam, would not be expected to give way and if it did a portion of Lake Bard would be maintained behind the detention basin that has been constructed at Wood Ranch.

SEVERITY OF THE HAZARD

Historically, two dam failures have affected the County. However, both of them occurred in much older dam structures that were constructed prior to modern engineering standards.

RESOURCES AFFECTED

Viturally all of the structures located within the flat valley floor of the Arroyo Simi would be affected by a catastrophic failure of Lake Bard. However, a partial failure would affect fewer structures and probably would be impounded behind the dam

at Wood Ranch.

NATURE OF THE INFORMATION

Excellent dam inundation maps have been prepared by the Calleguas Mutual Water Company for the Lake Bard inundation areas.

OTHER FINDINGS

Although dam failures have occurred in the past, the possibility of a modern, well engineered dam, especially the type that has been constructed at Lake Bard, make the chance of a dam failure extremely remote and should not be considered a serious hazard to the community of Moorpark.

FLOODING

Safety Element
CITY OF MOORPARK

JSA

Nothing under heaven is softer or more yielding than water, but when it attacks things hard and resistant there is not one of them that can prevail.

Tao Te Ching 240 B.C.

GENERAL DISCUSSION

GENERAL DESCRIPTION

A flood may be defined as a "temporary rise in stream flow or stage that results in water overtopping its banks and inundating areas adjacent to the channel." (Kusler, p. 54). The area subject to inundation is generally referred to as the flood plain. The size and frequency of occurrence of a flood in a particular channel depends on a complex combination of conditions, including the amount, intensity, and distribution of rainfall, previous moisture conditions, and drainage patterns.

The magnitude of a flood is measured in terms of its peak discharge, which is the maximum volume of water (in cubic feet per second) passing a point along a channel. However, floods are usually referred to in terms of their frequency of occurrence, which is related to discharge; for example, the 100-year flood for a particular channel is the size flood which has a probability of being equalled or exceeded once in 100 years. The magnitude of the flood selected by a governmental agency for planning purposes (usually 50-year or 100-year) is referred to as the selected or regulatory flood.

Flooding is a natural occurrence, with some long range beneficial aspects such as replenishment of sand to beaches and of nutrients to agricultural lands. It is a hazard only because people find flood plains a desirable place to live and use. Man's encroachment on flood plains can also increase the hazard: structures may obstruct the flood flow, thus increasing flood heights, and the covering of the ground with impervious surfaces (e.g. pavement) increases the rate and quantity of runoff.

GENERAL EFFECT OF THE HAZARD

The primary effect of flooding is the threat to life and property. People and animals may drown; structures and their contents may be washed away or destroyed; roads, bridges, and railroad tracks may be washed out; and crops may be destroyed. The amount of damage caused by a flood depends on the depth of inundation, the velocity and duration of the flood, the debris production of the watershed, and the erodibility of the bed and banks of the watercourse.

Much of the property damage from floods is caused by

the severe erosion which results from fast-moving flood waters. Serious damage can also be caused by the floating debris and sediment carried by flood waters. Floating debris (including parts of buildings, trees, etc.) can obstruct the flood flow, resulting in increased flood heights and overflow areas. Debris can also damage structures and bridges, and can damage or plug flood control channels. Mineral and organic debris and sediment deposited on the land as the flood waters recede create a huge cleanup problem and health hazard and can destroy crops and croplands.

Floods may also create health hazards due to the discharge of raw sewage from damaged septic tank leach fields, sewer lines, and sewage treatment plants and due to flammable, explosive, or toxic materials carried off by flood waters. In addition, vital public services may be disrupted.

A major secondary effect of flooding is the cost to local and national taxpayers. Evacuation, relief, and floodfighting services, cleanup operations, and the repair of damaged public facilities are all paid for by the public. Taxpayers must also bear a share of the cost of federal loans for reconstruction of private property and of damage claims under federally subsidized flood insurance. Another large expense arises from the construction and maintenance of flood control facilities to protect development from future floods.

The duration and extent of the hazard depend on the specific physical characteristics and conditions of the watershed and the intensity and duration of the storm. Generally, in Ventura County a flood builds up to a peak and then begins to recede, with the entire process lasting from an hour to a week, depending largely upon the size and slope of the watershed.

GENERAL INVENTORY OF THE HAZARD

Damaging floods at some locations in the county were reported as early as 1862; other floods were reported in 1884, 1889, 1911, 1914 and 1916. Floods for which data was recorded occurred in 1932, 1933, 1934, 1938, 1941, 1944, 1946, 1950, 1952, 1958, 1962, 1965, 1966, 1967, January 1969 and February 1969, 1978, 1980 and 1983.

The largest and most damaging recorded natural floods in the Calleguas Creek, Santa Clara, and Ventura watersheds occurred in 1969. (The St. Francis Dam failure in 1928 caused the largest known flood on the Santa Clara River). In 1969 the 50 and 100-year peak discharges were exceeded in many channels. The combined effects of the 1969 floods were disastrous: thirteen people lost their lives and property damage was estimated at 60 million dollars. Homes in Casitas Springs, Live Oak Acres, and Fillmore were flooded and 3,000 residents in Santa Paula and severel families in Fillmore were evacuated twice. A break in the Santa Clara levee threatened the City of Oxnard. Much agricultural land, primarily citrus groves, was seriously damaged. All over the county transportation facilities, including roads, bridges, and railroad tracks, were damaged. There was several million dollars worth of damage at the Ventura Marina. The Fillmore, Oak View, and Ventura sewage treatment plants were severely damaged, dumping raw sewage into the Santa Clara and Ventura Rivers and polluting beaches. In addition, sewer trunk lines were broken along San Antonio Creek, the Ventura River, and Calleguas Creek.

DEFINITION OF THE HAZARD ZONE

The boundaries of the hazard zone depend on the magnitude of peak discharge chosen for the selected flood. The Ventura County Flood Control District and most of the cities in the county use a 50-year flood as the selected flood, while the National Flood Insurance Regulations and most flood plain management literature use a 100-year flood. The Corps of Engineers has delineated 100-year (intermediate regional) and standard project floods (the largest flood that can reasonably be expected to occur).* For this study the Corps of Engineers 100-year flood plain is used as the hazard zone on the streams for which it has been mapped. (See Hazard Plate III)

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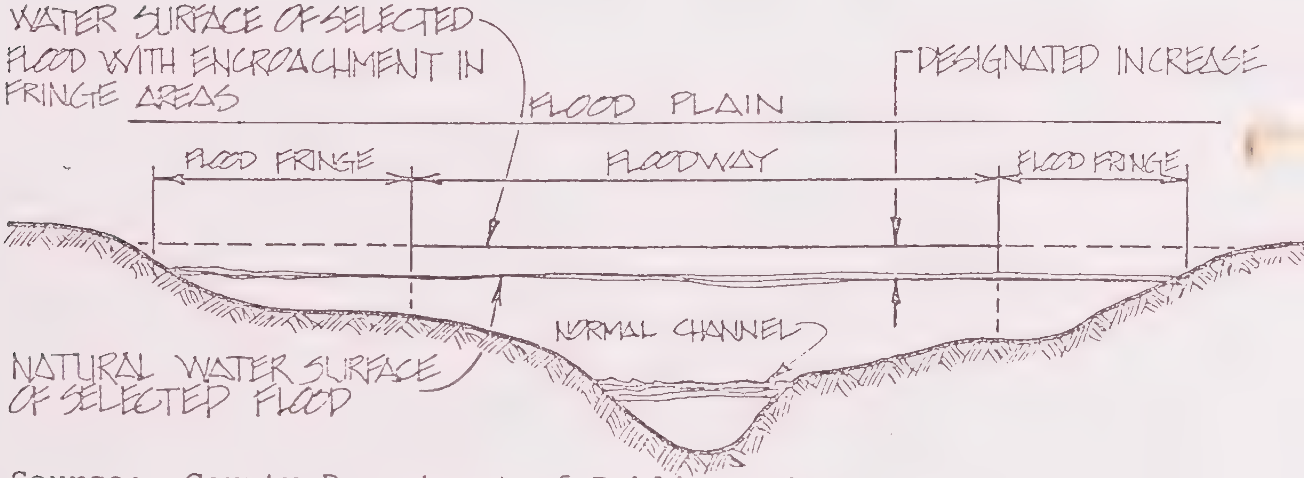
* The Flood Control District and the Corps base their calculations on different assumptions of watershed development and therefore get different results for flood magnitudes and overflow areas.

All presently available information on the geometrics of flood plains in the county is shown on the Hazard Plate. The 100-year and standard project flood plains of the Santa Clara and Ventura Rivers, Calleguas Creek (including Arroyo Simi), and Santa Paula, Sespe, San Antonio, and Conejo Creeks have been mapped by the Corps of Engineers. The U. S. Soil Conservation Service has mapped the 50-year flood plains of Revolon Slough. Flood plain limits for the other tributary channels have not yet been mapped. Many of these tributaries have flood control improvements over at least part of their courses.

The flood plain may actually be divided into two hazard areas: (1) the floodway, which is the portion that carries the deep and fast-moving water (usually defined as the area needed to contain the flood, allowing for a designated increase in flood height); and (2) the flood fringe area, which is the remainder of the flood plain.

Illustration 4.1. Flood Plain



Source: County Department of Public Works

NATURE OF INFORMATION

Flood plain limits are calculated from the best topographical information and hydrologic and hydraulic data and assumptions available. These delineations reflect existing conditions and changes in topography or land uses could affect these limits. Although the flood plains of many of the watercourses in the county have not been mapped, the Flood Control District has the capability to calculate the overflow areas for specific locations.

Floodway limits, which are extremely important for flood plain planning, have not yet been delineated for any channels in the county. However, the Flood Control District has begun a 5-year program of mapping flood plains and will soon begin to compute floodway limits (referred to as "designated watercourses") for the rivers and major tributaries. The computation and designation of floodways for all channels under the District's jurisdiction will take many years.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The Flood Control District has collected some data on flood discharges and topography and will soon begin delineating flood plains and floodways. At the request of the District, the Army Corps of Engineers has prepared Flood Plain Information Reports for eight major stream reaches in the county. These reports contain information on flood history and detailed maps and information on theoretical future flood profiles (heights) and corresponding overflow limits.

REGULATION

The entities responsible for regulation in flood hazard areas are the local governments and the Ventura County Flood Control District. The Flood Control District, which is governed by the Board of Supervisors, has the authority to maintain and construct flood control facilities on the channels shown on Hazard Plate 3. Ordinance FC-18, adopted in 1972, requires that a permit from the Flood Control District be obtained for most activities in "designated watercourses". At present, "designated watercourses" refers only to the bed and banks of the channels but once the floodways are mapped and public hearings are held, a portion of the overflow area inundated by a selected flood will be controlled by the Ordinance.

Outside of the designated watercourses, the prime responsibility for regulating activities in flood hazard areas lies with local governments. By State law land use and building restrictions to protect life and property from floods may be included in zoning and subdivision ordinances and building and sanitation codes. State and federal legislation has sought to encourage local governments to establish regulations for flood plains.

The Colbey-Alquist Flood Plain Management Act requires regulation as a condition for state assistance on federally authorized flood control projects.

The regulations of the National Flood Insurance Program (administered by the Department of Housing and Urban Development) require that communities adopt land use restrictions normally for the 100-year flood plain, in order to qualify for federally subsidized flood insurance. The types of restrictions communities must adopt are listed in some detail in the regulations; included is a requirement that residential structures be elevated above the level of the 100-year flood (see page for excerpts). Participation in the flood insurance program was recently made virtually mandatory by an amendment making flood insurance (in identified "special flood hazard" areas) a prerequisite for receiving mortgages or construction loans from federally regulated lending institutions. Although the county and all of the cities except Ojai are now on the eligible list for the program, most of these entities have not fully met the requirements considered optimal by the Federal Insurance Administration. It is highly probable that these entities will be required to upgrade their land use ordinances and regulations in the future in order to qualify for continuance in the National Flood Insurance Program.

WARNING

Flood warnings, issued by the U. S. Weather Bureau or the Flood Control District, are relayed to the public through the local news media and Sheriff's and Police departments.

ALLEVIATION

The flood hazard may be alleviated through a variety of measures, some corrective and some preventive.

Corrective measures include warning and relief programs, flood proofing of existing structures, and the construction of flood control works (channel improvements, levees, and dams). Structural works are the traditional means of alleviating the hazard, but they are extremely costly and are rarely able to keep up with development. Nationally, a half billion dollars a year is spent on flood control works, while flood damages average one billion dollars a year and are increasing. (Kusler, p. 3 and Sierra Club, p. 59). The cost of structurally protecting all the channels in the county Flood Control District's comprehensive plan has been estimated at over 300 million dollars, (V.C.F.C.D., the Great Floods of 1969, p. 2). Improperly planned structural works may also have

the effect of increasing downstream flood peaks and velocities and may contribute to beach erosion by reducing the amount of sand reaching the beaches. (Norris, R.M., p. 154)

Preventive measures for alleviating the hazard include public acquisition of flood plain lands, public information program, development policies, and regulations. The most effective means of preventing flood damage appears to be the regulation of the types of activities permitted in flood hazard areas. This approach is generally referred to as flood plain management. Flood plain management addresses the problems encountered in the utilization of flood plains; given the possible future land uses, the total spectrum of possible solutions to problems is considered. Flood plain management however, cannot protect all existing development. Therefore, to provide for the maximum alleviation of the flood hazard, a combination of corrective and preventive measures is necessary.

LOCAL DISCUSSION

FLOODING

LOCAL INVENTORY OF THE HAZARD

Areas of potential flooding exist within the City along Walnut Canyon, Grimes Canyon, The Peach Hill Drainage and the Arroyo Santa Rosa in Tierra Rejada Valley; but by far the most severe flooding hazard occurs on both sides of the Arroyo Simi from Simi Valley on down toward Camarillo. The flood plain in Grimes Canyon covers a more extensive area near its mouth until it reaches the channel at Los Angeles Avenue. The Peach Hill Drainage Channel is being improved during the construction of the Mountain Meadows Planned Community and will not constitute a flood hazard when it is completed. A good portion of the Tierra Rejada Valley would be flooded by a major flood occuring on the Arroyo Santa Rosa, especially the branch that comes down from the Thousand Oaks Treatment Plant to the south. The areas affected by the 100 year flood hazard are indicated on Moorpark Safety Plate III.

The Arroyo Simi, as always, will produce the major flooding within the City. Beyond Oak Park, the 100 year flood would spread out almost to Los Angeles Avenue throughout that section down to Virginia Colony and portions of Virigina Colony would be flooded. The new channel built between the railroad tracks and Moorpark Road downstream from Virginia Colony would contain most

of the 100 year flood. As it passes under the off ramp from the freeway, it would again spread and cover a large flood plain through the southern part of the City, again flooding almost up to Los Angeles Avenue in places until Walnut Creek is passed, at which point the flood would be constrained pretty well to the immediate area on both sides of the channel.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Walnut Creek flooding would not impact residential areas on either side of the creek. Grimes Canyon flood area appears to be mainly in agricultural use. The Peach Hill flood plain in the past has been in agricultural use and is presently being improved by the Mountain Meadows Planned Community. The Arroyo Santa Rosa flood plain is entirely in agriculture. The Arroyo Simi could affect residential properties in the Virginia Colony area in the 100 year flood plain, and the flood within the main town center itself could affect a large number of the properties south of Los Angeles Avenue from Moorpark Road west to Tierra Rejada Boulevard. This will affect industrial, residential and commercial properties. Most of the other areas are still in agricultural use or are vacant. The City Council and the Planning Commission have the authority to minimize the Flood Hazard through land use and building regulations. The existing regulations are contained in the Uniform Building Code and Subdivision Ordinance which require that buildings and other

improvements be protected from flood damage. This provision is enforced by the City Department of Community Development and the County Building and Safety under contract to the City and is based upon recommendations of the County Flood Control District. The standard condition on most developments are that buildings be protected by elevation, channel improvements, dykes or flood proofing from the 100 year flood.

FINDINGS

PROBABILITY OF OCCURRENCE

Floods are natural occurrences whose frequency and magnitude depend on the rainfall and the drainage patterns. It can be expected that the flood plain will be completely inundated on the average once every 100 years.

SEVERITY OF THE HAZARD

Several areas of the City are subject to serious flooding. Past floods indicate that extensive property damage and loss of economic production could be expected and it is even possible, in certain cases, that loss of life could occur. In addition, funding for flood damage relief is limited and costly to the

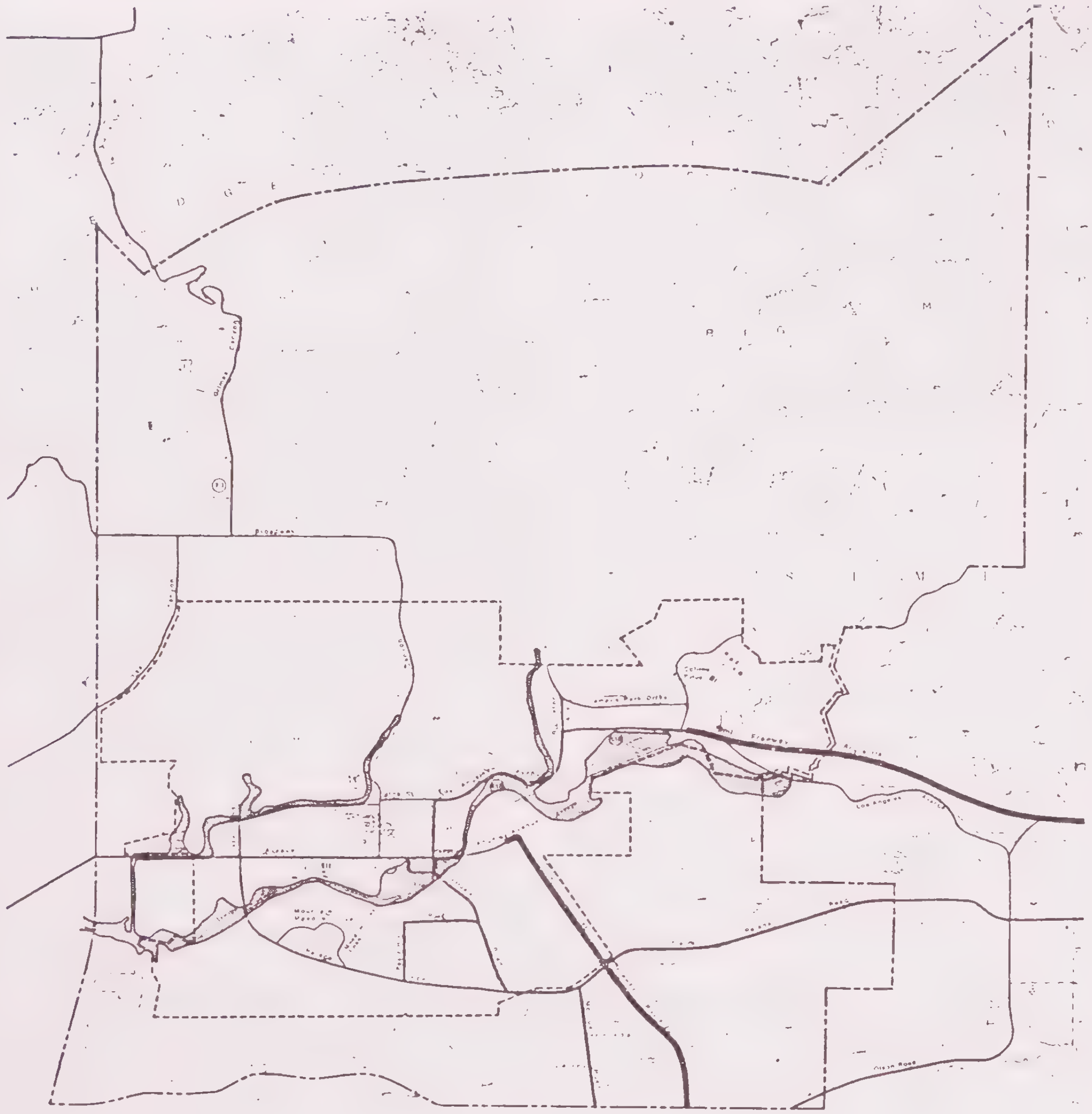
public in general.

RESOURCES AFFECTED

A number of residential, commercial and industrial facilities are located within the flood plain. Those and all public facilities and utilities should be periodically rechecked to indicate whether or not the flood conditions have changed relative to their present locations and to propose alternatives in case of damage from flood.

NATURE OF THE INFORMATION

Existing data is sufficient to calculate the overflow for specific areas. In addition, the County Flood Control District is constantly updating their flood plain maps in conjunction with the U.S. Army Corps of Engineers and the Federal Emergency Management Agency, National Flood Insurance Program and other findings. The most appropriate use for flood plains that are unprotected are for open space such as Greenbelts, Parks and some types of agriculture. Where development is permitted it should be safely elevated above the flood hazard level as required by Local, State and Federal Regulations.



Area Of 100 Year Flooding

LEGEND

AREA OF INTEREST

CITY LIMITS AND SPHERE OF INFLUENCE

MOORPARK SAFETY PLATE IV

Flood Hazard

CITY OF MOORPARK

JSA Joel Silverman & Associates

North 0 2000 4000 FEET

FIRE HAZARD

Safety Element
CITY OF MOORPARK

JSA

(Parve saepe scintilla contempta magnum excitavit incendium)

A small spark neglected has often kindled a mighty conflagration.

Quintus Curtius
1st Century A.D.

GENERAL DISCUSSION

GENERAL DESCRIPTION

Ventura County is a very pleasant place, both to live and to visit. The climate is warm and dry with gentle winter rains and clear summer skies. The view from the few flatlands in the southern part of the county is spectacular with rugged hills and mountains in most directions. The hills are green (or if not grassy, at least golden) all year long with brush and oaks at the low elevations and pine forest at the ridge tops. However, these same characteristics, in most senses, are clearly amenities, that make it one of the most hazardous fire areas in the country.

The climate in this area is generally referred to as "mediterranean" with rainfall concentrated in the most efficient months, during the cool winter when there is less evaporation. The rainy winters are caused by the dominance of cool, moist northern Pacific weather, which is characterized by the frequent passage of storm fronts followed by clear and temperate periods. These winter rains are stored in the ground and in the vegetation to assist it over the summer drought. The rains usually stop sometime in May and there is a drought, often lasting into November. This summer drought is the dominant characteristic of this climate. It is caused by the tropical desert air patterns that are dominant during this time period. Actually, this simplified model is not entirely correct, since the alternation of seasonal patterns is rarely exact and in consequence there is a high variability of rainfall and dominant weather patterns.

A local variation which aggravates the already fire hazardous situation is a local weather phenomenon that often occurs in Southern California when a low pressure trough develops off the coast and high pressure settles over the Great Basin of Nevada and Utah and over the deserts of eastern California and Arizona. The normal westerly wind flow is reversed and air pours in from the north and east, out of the deserts, down into the coastal basins and valleys. These are the Santa Ana winds which funnel through the mountain passes, growing warmer by compression as they decend. These winds arrive hot, dry and charged with static electricity and carrying dust. The extreme dryness, down to 1 percent or less relative humidity, desiccates the vegetation already dried by the drought.

This natural Southern California vegetation has adapted to this summer drought cycle. The annual plants, grass and wildflowers, mainly pass through the active phases of their life cycles in early spring, go to seed and die in early summer. While their demise is aesthetically pleasing, turning the hills golden and brown, the dry grass substantially increases the fire hazard. The perennial plants also have special adaptations to resist the drought. Most are naturally desert plants such as the sage that dominates in the coastal sage vegetation association, the sagebrush found in the yellow pine belt and the yucca which occurs in the chaparral. Their special adaptations include slow growth, small leaves and the abilities to both shed a portion of their leaves during summer drought and to develop waxy coatings on leaves to cut down evapotranspiration. Unfortunately, these latter two adaptations are major contributors to the extreme flammability of the chaparral and other plant associations which cover most of the steep hills between the beach and the pine covered hill tops.

Geologically speaking, the hills themselves are young and rugged, as witnessed by the fact that the sharp corners have not been worn off. These hills are still undergoing uplift at a rate of at least 25 feet per thousand years. Since the maximum rate of erosion is about 7.5 feet per thousand years (Erosion and Sediment Yields, U.S.G.S.), this means the streams are eroding, mainly by cutting straight down into their channels to produce deep canyons with steep precipitous sides. Given the combined effect of uplift and erosion, Ventura County tends to have a hilly landscape with very steep slopes.

Wherever these steep slopes are covered with the chaparral vegetation, after a few months of drought the fire hazard becomes extreme. It should be noted, however, that fire is a normal condition in Southern California. If it were not for the recurrent fires the chaparral would slowly be replaced by Oak woodland, a grassland with scattered live oak trees. Since man is the main cause of wildfire, it is perhaps appropriate that he is the main one affected. This is no new occurrence, of course, since it has been true since aboriginal man first arrived in this area. The Amerindian populations regularly deliberately lit fires to drive out game. These fires probably were the major contributing cause for the modification of the vegetation from oak woodland to chaparral.

Ironically, the longer an area goes without burning, either of chaparral or one of the other vegetation communities, the more fuel (both dry, dead material and growing plants) there is ready to burn. Thus, the more effective we are in preventing fires, the more likely they are to occur!

Fuel for fires is usually ignited by man, either directly by an arsonist, children playing with matches, individuals carelessness in smoking, debris burning, fireworks, campfires, and the like, or indirectly through accidents by man-made objects such as falling power lines, explosion of heaters or fuel tanks or by sparks from equipment hitting rocks or from engine exhaust. Natural causes, primarily lightning, are now relatively minor causes of local fires.

Although many fires are started every year, fortunately very few of them actually develop into major brushfires. The optimum conditions for large fires are: heavy vegetation with a thick layer of dead material, extreme dryness (usually found toward the end of summer) and high winds to provide abundant oxygen. These latter are usually Santa Ana winds, which also contributes to the dryness, and ignition. The resulting fire can spread very rapidly, at times consuming as much as 3,000 acres an hour. The steep hills help the spread of the fire by allowing it to burn rapidly up hill and frustrating fire suppression attempts. The worst condition exists whenever fire storms develop, large vortexes that concentrate heat and develop their own winds. Fire storms, which can jump freeways and the largest fuelbreaks, are almost impossible to control until weather conditions change.

Responsible public agencies in California, in general, and Ventura County in particular, have developed elaborate systems for fighting brush fires. When weather conditions become severe, all fire fighting personnel are put on alert. When a fire starts, all available personnel are rushed to the scene to keep the fire from developing into a major blaze. If the fire does get out of control and more than the county's own resources are required, mutual aid agreements are in effect with neighboring cities and counties to send additional aid. If the situation becomes a major problem, the State and even Federal aid is available for suppression of the fire.

Fire safety in urbanized areas must be evaluated in different terms than wildland fires. In this element, the aspects of fire protection in urban areas will be limited to an evaluation of evacuation routes, peak load water supply requirements, minimum road widths and clearances around structures. When discussing structural fires these points can be addressed in the same manner as wildland fires except for evacuation routes, which are defined in terms of removing the occupants from a burning or endangered building as opposed to evacuation from an area.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECT

In the short run, fire has its most widespread effects on the natural environment. However, a more detailed examination indicates that in some ecosystems wildfires in the longer run are actually beneficial. The chaparral associations (coastal sage, oak woodland, etc.) contain large numbers of pyrophytic plants, that require fire to reproduce or thrive, plus other plants that are resistant to fire using a number of adaptations. When these vegetation systems burn, the individual plants, and their associated animals are destroyed but the association survives and is actually improved by this natural selection.

A good example is the Potrero Fire that burned Point Mugu State Park in 1973. The scene was one of complete desolation following the fire. All the vegetation, including the Sycamores and Oaks, were burned and hundreds of small animals were killed. A month later, deer and birds were abundant and other animals were also on the rise. The burned remains of the brush was root sprouting (with the deer eating the shoots) and most of the burned trees were resprouting leaves. The vegetation and animals are projected to be back to normal in about three years but with the plants thinned out and the excess animal population culled, to the advantage of both.

Damage to man-made improvements account for most of the dollar loss from wildfires (aside from immediate suppression costs). The estimated value of the watershed lost forms the remainder of the total cost of the fire loss. Although developments in the hillside areas have a high value because of the view they provide, they are all too often built in dangerous brush covered areas. The ridge tops naturally provide more flat areas for house pads, (plus have the best view) and often the developments are put there with the canyons left undeveloped, remaining in their native vegetative state. Another contributing factor in the fire hazard is that of wood shake roofs; while considered the most aesthetically desirable roofing materials, they are extremely flammable. When a fire starts it burns up the steep hills, toward hilltop homes, making cantilevered homes particularly susceptible to fire on their undersides. The shake roofs ignite and the burning shakes help spread the fire, especially to surrounding buildings. The Bel Air fire of 1961, burned through communities developed on ridge tops, adjacent to brush filled canyon. Of the homes and other structures in the area of the fire, most of which had a high proportion of wood shake roofs,

484 residences and 21 other structures were destroyed and over a thousand others damaged. Significantly lower amounts of damage were sustained by structures (1) having non-flammable roofs, (2) having good brush clearance, (3) having their own pumps (water pressure was usually inadequate) and water supplies and/or (4) not located directly adjacent to brush areas.

In terms of control and prevention, the clearance of brush from around these structures can keep the main force of the fire from the building. This procedure is ever more effective when accompanied by regular replanting and maintenances of the canyon areas to make them less susceptible to ignition. In addition, the prohibition of shake roofs (or at least their limitation by requiring that fire proof roofs be interspersed with shake roofs) can significantly limit the spread of fires in new subdivisions. The maintenance of personal fire protection capability, such as gasoline pumps for using swimming pool water, reserve water supplies, roof sprinklers and other such preparations can also reduce the threat of fire damage.

Fire losses often include other structures such as sheds and barns, not to mention domestic animals. Other facilities are also affected, such as high tension power lines that can short out during a fire and other utilities and facilities located in the hazard zones.

The loss of life is higher in structural fires than in wildfires due to the warning time usually available in the latter. Occasionally, homeowners are injured or killed when they do not evacuate their homes (they can not be forced to leave) but most often civilian deaths are due to either people being trapped without warning or else an arsonist who cannot escape the fire he sets. Unfortunately, the largest number of deaths and injuries occurs to the firefighters themselves. Fires are notoriously unpredictable and occasionally they make sudden shifts that can trap even experienced firemen, as happened to 12 men in the Loop Fire near Los Angeles in 1966. The lives of professional firefighters are also lost in air and ground accidents while fighting the fires. This unfortunate loss of dedicated men is often due to the carelessness of others.

SECONDARY EFFECTS

The removal of vegetation by fire leaves the soil bare and open for erosion when the rains begin in the fall and winter. The fire kills the surface cover of vegetation, allowing the raindrops to hit the surface with

undiminished impact, splashing particles of soil loose which move downhill and is picked up by running water. The fire also destroys most of the roots that hold the soil in place, allowing running water to wash the soil away. Mudslides and mudflows are the results of these processes. Within the chaparral community another process increases the mudflow hazard. Under a chaparral cover, certain organic chemicals and compounds accumulate in the soil, making the soil non-wetable and impermeable to water. This produces what is referred to as a hydrophobic soil:

> If a slope is burned over by a fire of intense heat, the near surface zone is purged of hydrophobic compounds. The vaporized compounds condense in a cooler zone just below the surface. Rainfall could then penetrate the surface layer and reduce its shear strength. Any excess water would migrate downslope, just above the impervious layer, carrying away the weakened material as a mudflow. (California Geology, June, 1973, p. 134)

This hydrophobic effect helps account for the much higher mudflows from burned chaparral slopes. In January, 1969, following the 20,000-acre canyon fire of August, 1968, mudslides washed downslope into the City of Glendora, destroying homes and other property valued at some 8 million dollars. Many more millions of dollars of damage were caused by mudflows in Big Sur in 1972, following the Molera Fire.

The buildings that are destoyed by fires are usually eligible for re-assessment which reduces income to local governments from property taxes.

Public utilities are strained by fires, water supplies depleted, power lines are downed and telephone systems disrupted. Flood control facilities may be severely taxed by the increased flow from the denuded hillsides and the resulting debris that washes down. Recreation areas that have been affected must also be forced to close or operate at a reduced scale.

The fires themselves last at most, only a few days, but their effects can last much longer. If a grassland area has been burned it will resprout the following spring, a chaparral community, however, takes three to five years. An Oak Woodland which has had most of the seedlings and saplings destroyed by fire, will require at least five to ten years for a new crop to start. Most susceptible to long term damage are coniferous timber stands, which will take fifty to a hundred years for such a forest to re-establish itself.

ILLUSTRATION 14.1

1952 to 1973 Fires Over 1,000 Acres
Ventura County Fire Protection District

Name	Date Start	Structure Loss	No. of Structures	Areas Affected In County
Warring Canyon	9/14/52	$ --	--	2,153
Ventu Park	11/7/55	55,285	8	13,840
Red Mountain	/55	--	--	1,200
Sexton Canyon	12/26/56	--	--	2,500
Little Sycamore	12/57/56	5,425	5	1,617
Lake Sherwood	12/28/56	135,560	20	7,747
Conejo Grade	6/18/57	--	--	1,000
Santa Susana Pass	7/3/57	--	--	1,482
Boulder Creek	8/27/57	500	2	3,987
Calumet Canyon	10/21/58	15,355	5	17,000
Broome Ranch	11/26/59	--	--	1,350
Doncon & Fletcher	1/15/61	--	--	2,700
Culbert Lease	12/4/62	9,600	4	5,525
Warring Canyon	8/28/67	27,000	1	3,808
Sence Ranch	10/15/67	236,786	16	17,431
Ditch Road	10/16/67	27,748	13	1,120
Parker Ranch	10/16/67	323,790	48	25,000
Timber Canyon	10/16/67	6,650	8	11,448
Torrey Canyon	11/20/69	--	--	1,800
Ventura City Foothill	9/25/70	61,565	12	5,241
Mayo Brush	9/26/70	119,900	3	4,390
				7,290 Total
Goodenough Road	10/5/71	--	--	2,100
Potrero	9/26/73	1,650	3	12,214
Sence Ranch	9/26/73	--	--	1,008

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hillside portions of the county are the main areas affected by the "Fire Hazard" (see Hazard Plate VIII). Generally, agricultural areas lie outside the hazard zones, since their potential for fire damage is low, therefore, discussion of the entire Oxnard Plain in this regard is minimal. Due to its hilly nature, most of the north half of the county has been included within the high fire hazard zone, except for the inhabited valleys and certain meadow areas and desert scrub areas in the northwest. The urbanized areas of the county represent another type of fire hazard area, whose characteristics differ markedly from wildland fire hazard areas.

HISTORY OF THE HAZARD

Fires have burned through various areas of the county virtually every year for which records are available, and probably for centuries before that. The largest fire in the county and the state's history burned 219,000 acres, mainly in the Sespe and Matilija Canyon of Los Padres National Forest in 1932.

Twenty-four fires of over a thousand acres in size have burned in the county since 1952. The largest and most destructive of these was the Parker Ranch fire of 1967 which burned from Chatsworth to Thousand Oaks, consuming over 25,000 acres. This fire destroyed forty-eight structures with a value of $323,790. More recently, in 1973, the Potrero Fire burned through the entire Point Mugu State Park destroying more than 12,000 acres of chapparal and oak woodlands and forcing the park to severely restrict activities. This fire, like many others, was caused by man's carelessness.

DEFINITION OF THE HAZARD ZONE

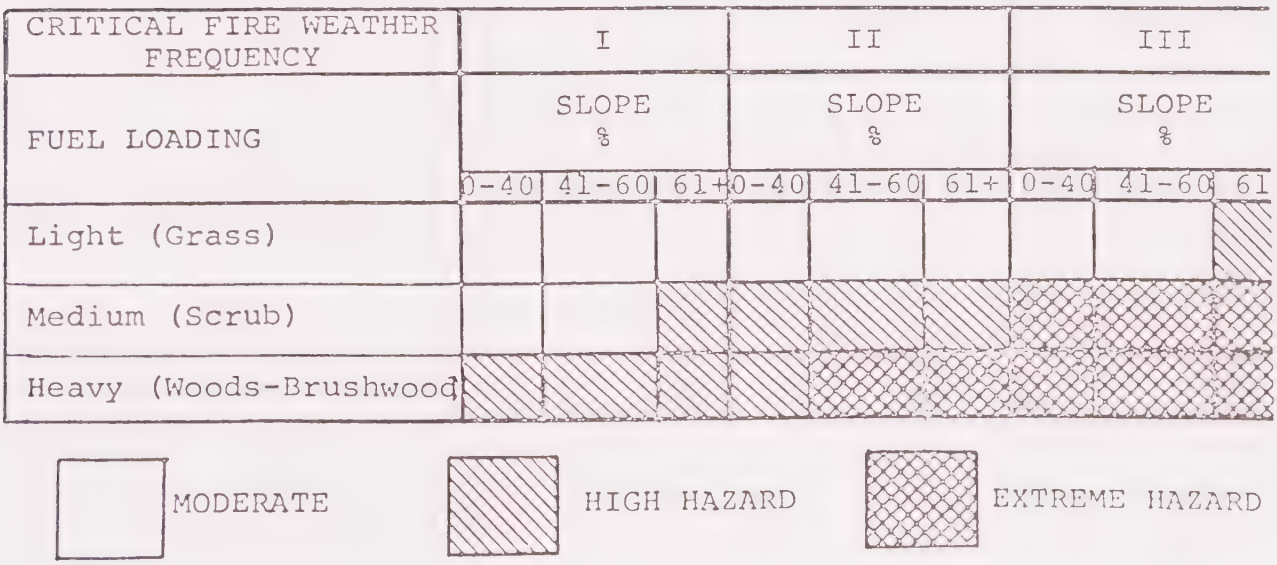
The California Division of Forestry has devised a "Fire Hazard Severity Classification for California's Wildlands". This classification identifies fuel loading (the quantity of flammable vegetation and other fuel per unit of land area), fire weather, and slope as the primary criteria for classifying fire hazard in varying degrees of severity. This classification was developed to provide "local government and land use planners with a practical and logical system for classifying and delineating areas of varying severity of fire hazard". (Fire Hazard Classification, p. 1)

U. S. Geological Survey (USGS) topographic maps have been used as a basic tool in defining a series of classes for each of the three criteria. Fuel loading includes three classes (on Illustration 2). Light fuels occupy the uncolored areas on the USGS maps, outside of agricultural, urban or watercourse areas, and represents flammable grasses and annual herbs. Medium fuels are shown as "scrub" on the USGS maps and include brush and other perrennial shrubs less than six feet in height and having a crown density of 20 percent or more. Heavy fuels are shown as "woods-brushwoods" on the USGS maps and include heaview brush species, woodland types and timber types over six feet in height and having a crown density of 20 percent or more (Fire Hazard Classification, p. 7).

In the Fire Weather Classification there are three classes related to the frequency of critical weather days occurring in each of the state's Fire Danger Rating Areas over a ten-year period (Illustration 14.2). The entire County of Ventura falls in the extreme class (Class III) with an annual average of more than 9.5 critical fire weather days (Fire Hazard Classification, p. 15).

There are also three slope classes (Illustration 14.2) derived from California's Interagency Wildland Fire Danger Rating System. Slope is reocgnized by that system as having an effect on fire behavior similar to the effect of wind, i.e., an increase in slope produces an increase in the rate of fire spread. In analyzing the county, there were only two small areas of over 60% slope, which were grass covered and they were included in the extreme area.

ILLUSTRATION 14.2
Fire Hazard Severity Scale for Delineation
of California's Wildlands



As indicated in Illustration 14.2, there are only two levels of severity for Ventura County - The Moderate and Extreme Fire Hazard Areas. These areas are delineated on Hazard Plate VIII.

NATURE OF THE INFORMATION

The hazard zones delineated on Hazard Plate VIII are derived strictly from the criteria of the State Division of Forestry. This system relies a great deal on the cartography of the USGS. However, no vegetation map that has been completed for the county has had more detail than the USGS Quadrangles (at a scale of 1:24,000 [1 inch = 2,000 feet]).

The agricultural and urban areas of the county cannot be considered wildlands for purposes of this classification. Isolated watercourses contain vegetation that is moist year round and, therefore, has a lower fire hazard. These areas are only included if they are near wildland areas or contain large amounts of vegetation that is seasonally dry.

The vegetation information will be updated during the 1974-75 fiscal year by the Ventura County Planning Department and the U. S. Forest Service. The fire hazard zones will be revised to meet Federal Firescape criteria when it is formally adopted.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The Ventura County Fire Department constantly monitors the fire hazard in the county. They have ongoing programs for investigation and alleviation of hazardous situations.

The Ventura County Planning Department, in cooperation with the County Fire Department and the U. S. Forest Service, will do a vegetation map of the county to help in the further determination of fuel loading characteristics. This hazard element will be updated as necessary.

PEAK LOAD WATER SUPPLY REQUIREMENTS

The water supply for any structure is determined by a complicated formula in the "water works" ordinance. This ordinance was written and is enforced by the County Department of Public Works and City Public Works Departments. It requires a minimum fire flow of 500 gallons per minute (GPM)

in residential areas, 1,000 GPM minimum in commercial areas, and 1,500 GPM minimum in industrial areas. The peak demand rate is the peak domestic flow or the fire flow plus ½ the peak domestic load whichever is greatest. These flows are minimum requirements only and greater flows may be required by the Fire Chief.

MINIMUM ROAD WIDTHS

The entire county has the same road width requirements except for Thousand Oaks, whose minimum is slightly larger. All are adequate to allow fire access. Thirty-two feet is the minimum width for a cul-de-sac or loop road. A cul-de-sac must have a minimum radius of 40 feet. Thirty-six feet is the minimum road width for a residential minor road. All other roads have larger minimum widths.

CLEARANCES AROUND STRUCTURES

The best way to protect a structure, in the hazard zone, is to clear all flammable concentrations of brush from around the structure. Otherwise, this brush can provide an avenue for the fire to approach the building. Well maintained ornamental plantings do not burn readily although there is no plant that will not burn under the right conditions. To reduce the fire hazard, four steps can be taken. (Landscape, p. 1)

1. Increase effectiveness of plantings with a high pressure sprinkler system.

2. Keep landscape clean. Remove litter under trees and shrubs; prune out deadwood. Remove dead and dried portions of ground covers and succulents.

3. Leave space between remaining shrubs and trees to help prevent fire spread.

4. Plant lawns, succulent ground covers, or other low growing plants around all structures, and water regularly. Do not allow continuous tree or brush canopy next to buildings. (Landscape, p.1)

If plantings cannot be used, a minimum clearance of brush is necessary to protect the building from the spread of fire. A minimum clearance of 30 feet is required around all structures, increasing to 60 feet clearance in high grass and low brush areas and up to a 100-foot minimum in any high brush area. If the property owner does not clear his land it will be done by county crews and the owner billed for the expense. These clearances do not apply to ornamental trees and shrubs or ground cover less than 18

inches high "provided they do not provide a means of rapidly transmitting fire from the native growth to any structure". (Uniform Fire Code, 1973, p. 257, Art. 16a2, Appendix E)

Orchards provide a good fuel break in most cases - if the trees are maintained. For example, a belt of orchards already protects much of Santa Paula. Eucalyptus trees are also used for wind breaks; however, they must be kept very well trimmed or they can transmit a fire down their entire length circumventing any fire break provided by an orchard or field.

FUEL MANAGEMENT

Many forms of fuel management have been employed as a means of fire control, including firebreaks, fuel breaks, vegetation conversion and controlled burning.

Fire breaks are probably the most common and have been used the longest. They consist of clearing an area from 50 to 200 or more feet wide (of all flammable material) usually along a ridge top. Unfortunately, these fire breaks tend to be highly susceptible to erosion and are aesthetically not very pleasing.

Fuel breaks are much larger, 200 to 600 feet wide where all but scattered plants and grasses have been removed. These breaks have been effective in stopping wildlife and have a parklike appearance. However, they take more maintenance than a fire break, which can be cleared by quickly bulldozing over it. (Also, the herbicides often used to construct fuel breaks have created much controversy.) A proposed alternative introducing plants for fuel breaks, has not proven effective, as yet. Such vegetation conversion requires the removal of the natural vegetation and the replacement with other less flammable ones. The expense is high for this type of management program and as yet no acceptable plant has been able to compete with the native chaparral species in an unmanaged environment.

Controlled burning is a process by which the highest hazard areas are burned during the safest times of year, with the conditions as much as possible controlled before the fire is started. The biggest problem is that once a fire is lighted it is never truly "under control" since it can only be stopped at certain boundaries. If conditions change suddenly these boundaries can be breeched. Also, the Air Pollution Control District restricts controlled burning to certain days when the weather conditions are correct; these days are not always the safest in terms of fire control.

However, all things being considered, controlled burning seems to be the best fuel management method presently available. Controlled burning for range improvement and fire protection has gone on for centuries. Ranchers in California working with Division of Forestry and University of California Research and Extension Services have developed quite involved controlled burn procedures. In Ventura County, these private controlled burns are under the supervision of the supervision of the County Fire Department and are encouraged by them.

The U. S. Forest Service is instituting a controlled burn program in the Los Padres National Forest this fall and plans to continue it as an ongoing conflagration prevention, fuel management tool. The Ventura County Fire Department also encourages controlled burns and they have used them to protect communities such as Santa Paula.

WARNING AND EVACUATION

In the case of a major wildfire, owners of homes and inhabitants of communities, in the path of the flames, are warned of the threat and evacuation is recommended if the threat is eminent. The responsibility for warning and evacuation is in the hands of the law enforcement agencies, primarily the Sheriff's Department, since most fire hazards exist on unincorporated county territory. Evacuation can only be recommended, not ordered, since no one can force a person to leave his house. Formal evacuation routes are not predetermined, due to the unpredicability of a fire. Thus, law enforcement agencies react accordingly to a given situation.

SUPPRESSION

Outside of the boundaries of Santa Paula, Fillmore, Oxnard, San Buenaventura, and the Los Padres National Forest, the Ventura County Fire Department has responsibility for wildland fire suppression on all private land. Normally much of this area would be the responsibility of the California Division of Forestry but the county has contracted with the state to assume this task, in return for payment by the state. The county has mutual aid and automatic aid agreements with the four city fire departments and the surrounding counties and cities. These mutual aid agreements obligate the departments to help each other in case of a major fire, if requested. Automatic aid agreements obligate the nearest fire company to respond to a fire regardless of the jurisdiction. The State Office of Emergency Service can be called upon for further aid, if necessary, as can Federal agencies, including the Department of Agriculture, Interior, and in extreme cases, Defense. Private companies and individuals have also assisted,

upon request, during major fires.

Ventura County is lucky to have an outstanding Fire Department with an excellent well-deserved reputation. They have good equipment in most areas, the major exception being their lack of an up-to-date air capability. To compensate for this lack, they have access to air tankers from the state and by mutual aid agreements from the U. S. Forest Service. However, other fire fighting agencies such as Los Angeles County and the California Division of Forestry have found that their response capability is much improved with the use of large modern helicopters such as those that were developed for the Viet Nam War. These "Hueys", or their civilian counterpart the Bell 204-B, can carry 350 gallons of water, a fire retardant, or an eight man fire crew. These helicopters can be used for ferrying crews to remote fires for early suppression or for dropping retardant or water on small blazes to keep them from spreading. Fire Bosses on major fires have found them to have important advantages over the air tankers. With portable mixing equipment, which can be moved right to the fire line, "helitankers" can deliver retardant to the fire with a round trip time of 3 to 5 minutes. Helicopters have an edge over air tankers in terms of total gallons of retardant delivered, accuracy of drop and costs per gallon of retardant delivered. The larger aircraft has other advantages so that the two complement each other. (California Aflame, p. 50) The larger aircraft can provide larger volume per drop and greater speed and range. At the present time, the County Fire Department is scheduled to acquire a helicopter in 1977, according to its 1975-1985 Plans and Programs budget.

AFTER THE FIRE

Numerous relief agencies, such as the Red Cross, become involved in case of a major fire. They provide disaster relief to the victims and provide medical aid and assistance to the fire fighters. In case of a major disaster, state and even federal relief is possible, including low interest loans to individuals and local governments.

The reseeding of private land after a fire is the responsibility of the California Division of Forestry. After a fire they send in range and soil specialists to determine if emergency revegetation is necessary to prevent mudslides. In the past, the Ventura County Flood Control District has cooperated in some reseeding projects.

LAND USE DECISIONS

The Board of Supervisors and the City Councils and the various Planning Commissions have authority over land use decisions in fire hazard areas. Fairly simple design criteria can be used to make hillside developments relatively safe from fire. There are also fuel management methods that can be used to reduce the fire hazard to hillside developments.

Fuel break design criteria is available for the initial clearing program. The maintenance of these areas in a fire safe condition along with increasing vulnerability to erosion and slide problems presents a continual high maintenance expense that must be borne. Structural encroachments upon hillsides generates a number of problems:

1. Increases direct cost in maintenance of public services and amenities.

2. Increases fire risk in the adjoining highly inflammable brush areas. (Children playing with matches, etc.)

3. A reduction in the capability of fire suppression forces to accomplish their mission.

   a. Initial attack time is extended due to road grades and curves.

   b. Fire spread rate and intensity is increased due to slope factor.

   c. A potential net loss of strategic locations to fight a fire from.

   d. A built-in dilution potential of available suppression forces. (Forces are diverted to protect individual structures rather than concentrate on the key fire locations.)

   e. A potential loss of suitable strategic locations to construct fuel breaks, greenbelts or other fire prevention measures to protect from fires burning into or out of communities and the adjoining wildlands.

Structural development on slopes where the above factors cannot be internally mitigated are not in the public interest and should be discouraged.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The County document that proceeds this section was prepared in 1974 and since that time, a number of major fires have affected the County and the City of Moorpark itself. In 1985 alone, three major fires affected the City, including the Peach Hill area, the Fairview area and the Tapo Canyon fire which burned from north of Simi Valley all the way down past the area of the college. This was in the fire season of 1985. A number of major fires have affected the area in previous years.

Virtually all of the local hills are covered by native brush known a coastal sage shrub vegetation association, unless the vegetation has been removed and the areas to developed or put into agricultural production. Areas of natural brush can be considered to have a fire hazard at all times except immediately after the rainy season. By late fall, the fire hazard becomes extreme and major conflagrations can occur. However, the fuel loading in the costal sage shrub is much lower than other areas of the County such as Thousand Oaks and the Santa Clara River Valley which have heavy chaparrel vegetation which is generally not present in this area. Agricultural areas have a lower fire hazard potential due to the irrigated nature of the crops grown.

However, they too, present a higher fire hazard than a developed area which has cleared brush.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Virtually all of the City is within or in fairly close proximity to a high fire hazard area. Therefore, it is necessary to meet certain minimum fire protection standards such as brush clearance and protection of flammable roofs and other flammable structures in case of a major fire within the area. Fortunately, most facilities constructed within or adjacent to the hazard zone, are built and landscaped in such a way that damage from fire is greatly reduced. For example, Moorpark College built in an isolated area is surrounded by parking lots on the hazardous sides and is carefully landscaped and well tended which makes it very fire resistant. Most other portions of the community also contain careful landscaping and brush clearance to protect them from fire hazard.

PROBABILITY OF OCCURRENCE

Fires erupt every year within Ventura County. The areas that have high brush and have not burned for quite some time are most susceptible to fire. Most areas of high hazard have burned at least once within the last 50 years. Therefore, these areas

could be expected to burn again in the next 50 years, unless some method of fuel management is undertaken.

SEVERITY OF THE HAZARD

The effects of a wild fire on an area depends a great deal upon the preventive measures and recovery actions following the fire. The various fire agencies will make every possible effort to save structures during the fire, but their effectiveness depends on the preventive measures taken before the fire. If the brush has been cleared, a fire resistant roof installed, a sufficient supply of water is available and access is provided for the fire equipment, then there is an excellent chance to avert major damage. The chances decrease proportionately if any of these precautions are not taken.

After a fire, efforts must be made to reduce the risk from mudslides. This includes seeding areas by the State Divsion of Forestry, the Ventura County Flood Control District or the individual homeowners. Even if reseeding has been undertaken, precautionary measures should be taken to protect communities or individual structures from mudslides. The Ventura County Flood District distributes a homeowners guide for debris and erosion control in case of a mudslide threat.

RESOURCES AFFECTED

Those portions of the community located adjacent to the hazard areas could be affected, but there are a few critical facilities located in the hazard zone that are not adequately protected. Due to the excellent County fire protection afforded to the community, there are few structures which are located great distances from a local fire department. However, on those structures located in extremely rural areas, the homeowners should be especially careful to make their building inherently fire safe.

NATURE OF THE INFORMATION

Although the data regarding the hazard zones on the County Hazard Plate is somewhat generalized and was compiled from old sources, it is adequate for planning purposes since the zones themselves, change very little in the long run unless affected by man. However, any maps produced locally would be outdated in just a few years by any change in agricultural production or development and therefore, local hazard maps have not been developed, but simply verbally described as brush covered area within the community.

OTHER FINDINGS

The hazard of major fires will continue in the community as long as man interacts with the natural vegetation. The hazard can be reduced by an effective ongoing fuel management program. It is more reasonable to spend the funds to control hazardous areas before a conflagration occurs than to spend larger sums to fight the inevitable fire with a resulting threat to life and property.

.he County Fire Department which provides fire protection for the City of Moorpark will need continued support in terms of replacement of equipment and expansion of services and capacity if it is to remain in its present high standards and meet the needs of the community's growing population.

EXPANSIVE SOILS

Safety Element
CITY OF MOORPARK

JSA

Expansion means complexity and complexity decay.

Parkinson's third law

GENERAL DISCRIPTION

Expansive soils (which are identical to soils referred to elsewhere as having a shrink-swell potential) are those which are generally clayey, expand or swell when wetted and contract or shrink when dried. Wetting can occur naturally in a number of ways, i.e., rain, absorbtion of water from the air, groundwater fluctuations, as well as from other sources, i.e., lawn watering, broken water or sewer lines.

In the 1960's, epansive soils caused severe damage to many housing developments. While significant construction deficiencies were noted, more conservative engineering design provisions and regulations were initiated which effectively eliminated the hazard to future construction. Subsequent engineering studies have resulted in tests and design procedures which provide safe and economical design for expansive soils. Local building ordinances have incorporated these concepts in recent years.

The only area relating to expansive soils which must continue to receive special attention, is downslope soil creep in hillside areas. As an expansive soil expands and contracts, it tends to move downslope in response to gravity. Recognition of this condition by all parties should not be overlooked. This condition may require flatter slopes, soil removal and special landscaping and irrigation treatment.

GENERAL EFFECTS

Fully 20% of this nation's land area will be affected by expansive soil movements during the period of the average person's lifetime. Typically, expansive soils are located in areas generally most attractive for intense, urban type uses. The movement of expansive soil may be slow, progressing over a period of years. Commonly, this movement is associated with seasonal or even longer wet/dry cycles. (Civil Engineering, 1973, p. 49).

PRIMARY EFFECTS

These soil movements can cause structural damage to houses, pavement and utilities in two ways. First, the expansion of the soil can cause it to heave and thus place direct pressure on a structure. Alternately, soil expansion can lead to the loss of support under part of a structure. This can occur during swell conditions if the saturated soil shifts due to the weight of the structure, or in dry conditions if the soil shrinks and support is withdrawn.

Damage can range from the impaired functioning of doors and windows through plaster and foundation cracks to total destruction in extreme cases. Often water from a leaking sewer line is responsible for causing the soil expansion which damages a home. Annually, some 250,000 homes are built on expansive soils in the United States and 10% of these will experience "significant damage." Nationally, at least $2.3 billion is lost annually due to damage to houses, buildings, roads and pipelines. Records exist of expansive soils causing damage to highways, buildings, reservoirs, swimming pools, canals and utilities of all types. (Civil Engineering, 1973, p. 49).

SECONDARY EFFECTS

The main secondary effect of expansive soils to structures not designed against the condition is monetary loss.

GENERAL INVENTORY

LOCATION

Three expansive soil zones have been mapped; and they appear on Hazards Plate VI. Derived from the Soil Conservation Service's 1970 Soil Survey, this map designates high, moderate and low expansive zones. This is a generalized version of individual soils maps. It generally indicates those areas where expansive soils are present. (See Soil Survey in Ventura Area, 1970).

A more specific map was prepared for each entity, and the degree of expansiveness may not conform precisely to Plate VI even though both utilize identical categories of expansive soils. The reason for this is that the local maps were taken from the non-generalized maps developed by the Soil Conservation Service and thus display a greater level of detail.

While the general and specific maps are quite useful for locating large areas of potential hazard, it must be stated that they cannot be used in lieu of site inspection when construction is considered. Experience in the Building and Safety Department indicates that a soils test at the specific site is necessary because this hazard is so localized in nature.

HISTORY

In the early 1960's numerous homes were lost and many more were severely damaged in the Shadow Oaks Tract. Adjacent to the City of Thousand Oaks, this area experienced soil expansion which cracked many 2-inch thick slabs. Other areas of the county have also experienced problems due to soil expansion, specifically the Camarillo Heights Area. However, here the damage has not been as great because many lessons were learned in the Shadow Oaks case.

As the damage started to appear in the new homes of this tract, many of them were vacated. Still others remained occupied but some people stopped making their payments. Many houses were rented, a transient group of people occupied these and the neighborhood generally declined.

In time, repairs saved some homes while others were replaced using more cautious construction techniques. The slabs were increased in thickness up to 9 inches. In time, this requirement was refined and relaxed in cases where soils tests revealed minimal shrink-swell potential. The Shadow Oaks case was primarily responsible for the establishment of more stringent building code requirements which have effectively eliminated the expansive soils problem in Ventura County.

NATURE OF INFORMATION

General information concerning the shrink-swell potential of the county's soils has been provided in the Soils Survey by the Soil Conservation Service. This information is useful but its limits must be recognized.

Expansive soil is so localized in occurrence that it is necessary to test each site and gauge construction to the specific soil conditions. A range of design requirements and construction techniques must be met according to the expansive quality of the soil. It appears that no further information is needed about the general occurrence of expansive soil in the county. However, investigation is needed for each site and this is being accomplished as specific proposals for development are made.

It is generally accepted that the expertise exists to both identify the problem and provide solutions. Soils engineers can locate problem areas and foundation engineers can design counter measures. The ability to control and minimize damage from expansive soils is such that the State in its Urban Geology Master Plan sees no need to either institute new or change existing programs. Merely implementing existing programs to their full extent is the recommendation of this State report.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

For the county in general, the United States Department of Agriculture and the University of California Agricultural Extension have investigated the occurrence of expansive soils in their Soil Survey. This investigation shows a scattering of such soils and thus indicates the necessity for individual investigations of local soil conditions. Building regulations in unincorporated areas require appropriate soils tests, but some city requirements are not always so stringent on this point.

REGULATION

Numerous agencies have established standards to eliminate the potential for structural damage due to expansive soils. Both HUD and FHA have codes to be followed if expansive soils are present. The United States Department of Agriculture in conjunction with the University of California Agricultural Extension Station have recommendations based on their Soil Survey of Ventura County. In addition, the State Subdivision Map Act and the Uniform Building Code exert some control in areas where this hazard exists. Various city and county ordinances similarly speak to this issue.

Within Ventura County a soils engineering report is required in certain cases when a tentative tract map is submitted to the County. It is necessary, according to Section 8225 of the County Ordinance, when a hillside area is part of the proposal. If expansive soils exist, the soils report should reflect this condition.

In the case of the construction of buildings, the County Department of Building and Safety requires a soils test for every unit in the unincorporated territory except for sandy beach areas.

ALLEVIATION

Steps would have to be taken in the grading and construction phases of a subdivision in order to assure protection against this hazard. Among the corrective measures which might be employed are various foundation construction techniques including proper drainage. The degree of expansiveness, as revealed in the expansion test, dictates the type of foundation design. If the expansiveness of a soil exceed a set limit, then a special engineering design is required for that site and building (Building Regulations, 1973). Responsibility for enforcement of County ordinances for grading rests with the Department of Public Works, and with the Department of Building and Safety for buildings (structures). Similar responsibilities rest with these respective departments of each city in the County, unless the city contracts with the County for services.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

There are a number of areas surrounding the City of Moorpark which have very high shrink/swell potential in the soils. These include the area immediate west of Happy Camp Canyon, and from Virginia Colony, about half way over to Walnut Canyon; the area at the extreme eastern end of Broadway Road and some scattered areas near the western end; a large area in Grimes Canyon; the Moorpark Home Acres area and a large area surrounding the Tierra Rejada Valley, including most of the valley floor. There are some other scattered areas of shrink/swell soils near the college and just east of Grimes Canyon and in the hill area back of Peach Hill. The hazard is indicated on Moorpark Safety Plate V.

LOCAL RESOURCES AFFECTED BY THE HAZARD

The resources most often affected by expansive soils are structures. Even though expansive soils are found throughout the community, their potential impact on structures is limited to just a few developed areas within the City. The presence of expansive soils in these developed areas presents no threat, if

property designed and constructed because soil tests and engineering solutions can overcome the dangers of expansive soils.

LOCAL MANAGEMENT RESPONSIBILITY

The County Building and Safety Department oversees building permit and inspection processes for the City. These processes have effectively ended the dangers of expansive soils in approved and inspected structures and include soil tests at each construction site and enforcement of building standards keyed to varying degrees of expansive soils.

FINDINGS

PROBABILITY OF OCCURRENCE

Areas of expansive soils exist throughout the community of Moorpark. Especially with the City's seasonably rainy/dry periods, it can be assumed that local soils will have the opportunity to shrink or swell if they have significant clay content.

SEVERITY OF THE HAZARD

Historically, expansive soils have caused considerable damage in Ventura County. Since the initial damage in the eary '60s, the problem has been studied and corrected as new construction techniques have been developed. This has allowed construction even in areas where the hazard is severe. Through proper investigation and design, the potential for damage can be effectively eliminated.

RESOURCES AFFECTED

Prior to requiring comprehensive soils reports, damage in Ventura County was confined to a few areas, especially Camarillo Heights and the Shadow Oaks Tract near Thousand Oaks where newly constructed houses were affected. Expansive soils are generally localized in occurrence, so designation of hazard zones on a large scale map are not usually adequate for purposes of providing protection. Therefore, detailed maps have been prepared for the City and constitute Moorpark Safety Plate V. These maps have been prepared using the detailed 2,000 scale aerial photographs provided in the Soil Survey of Ventura County by the U.S. Soil Conservation Service of the Department of Agriculture.

NATURE OF THE INFORMATION

Basically, the information available from the maps and from the Soils Survey are adequate to designate areas which contain a high potential for shrink/swell soils. Property can be protected from damage caused by expansive soils through proper construction technology. Soil tests can reveal if a problem exists and if it does, the degree of hazard can be defined and mitigated.

OTHER FINDINGS

Proper foundation construction can prevent damage if a threat is shown to be present. Therefore, the only action necessary to prevent damage is a process which requires the appropriate soils information developed and applied to the specific site.

APPENDIX

APPENDIX I

An attempt has been made to define all technical words contained in the text. If a technical word is not defined, often the word can be found in a standard dictionary. In using the glossary, the reader will note that many technical words appear within the definitions themselves. Definitions of these words can also be found in the glossary.

Active faults. Active faults are faults which show evidence of any or all of the following:
1. Topographic or physiographic expressions suggestive of geologically young fault movements.
2. Fault creep.
3. Records of surface rupture within or adjacent to the study area in historic time.

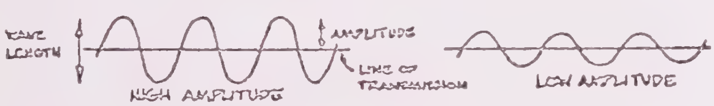
Aggregate. Materials such as sand, gravel, and crushed rock, with which cement or bituminous material is mixed to make concrete or asphalt.

Alluvial fans. Alluvial fans are built by rivers flowing from mountains onto lowlands. They are low cone-shaped heaps, steepest near the mouth of the valley, and sloping gently outward with ever decreasing slope.

Alluvium. A general term for the sediments laid down in river beds, flood plains, lakes, fans at the foot of the mountain slopes, and estuaries during relatively recent geologic times.

Amplification. The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

Amplitude. One-half the elevation of the crest of a wave or ripple above the adjacent troughs:

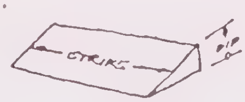


Anomaly. A deviation or inconsistency of a specific land feature from uniformity with the larger area.

Anomalous features. See "anomaly".

Anticline. An upfold or arch of rock strata formed by internal earth pressure forming a shape like the roof of a house. Erosion could alter this shape leaving only the inclined strata.

Attitude (of rock structures). A term including the terms dip and strike. The attitude of the flat surface of a sedimentary bed, whether inclined or not, is referred to the horizontal plane. Dip is its slope inclination (in degrees) from this plane, and is measured with a clinometer. Strike is the compass bearing on the line of intersection of its surface with horizontal plane. The terms may also apply to faults, veins, and dikes.



Basalt. A dark-colored, fine-grained volcanic rock, composed essentially of the mineral plagioclase feldspar and one or more dark minerals such as pyroxene.

Bed. The smallest division of a stratified series, and marked by a more or less well-defined plane from its neighbors above and below.

Bedding plane. In sedimentary or stratified rocks, the division planes which separate the individual layers, beds or strata.

Bedrock. Any solid rock underlying soil, sand, clay, etc.

Berkeley hills. The hills on the immediate east side of San Francisco Bay contained within such cities as Oakland, Berkeley, El Cerrito and Richmond.

Bore hole. A hole drilled into the earth for exploratory purposes.

Breccia. A rock composed of angular coarse fragments, commonly cemented together.

Chert. A compact sedimentary rock containing abundant quartz of organic or precipitated origin.

Clastic rock or Clast. A rock which is composed principally of detritus transported mechanically into its place of deposition.

Cohesion, rock. The capacity of a rock to stick or adhere together. In effect the cohesion of soil or rock is that part of its shear strength which does not depend upon interparticle friction.

Cohesive materials. See "cohesion, rock".

Colluvium. Soil deposited by soil creep, landslides and surface wash.

Compaction. Decrease in volume of sediments, as a result of compression of sediments deposited above them.

Competent beds. Those beds or strata which, because of massiveness or inherent strength, are able to lift not only their own weight but also overlying rock. Therefore, such rock material is especially able to withstand failure such as landsliding.

Conglomerate. A rock composed of larger fragments (such as pebbles or cobbles) set in a matrix of finer material (such as sand, silt, and/or clay).

Consolidated material. Soft or hard rock which requires some medium of loosening at the excavation site before it can be handled. The more loosening required (i.e., blasting as opposed to bulldozing) the more consolidated the material.

Continental rock. A rock unit laid down on land as opposed to one laid down in marine water.

Contra Costa Group. The type of poorly consolidated young sedimentary rock found in the Tri-Cities Area east & north of the Berkeley hills ridgeline.

Creep, fault. See "fault creep".

Cross bedding. The arrangement of narrow layers of sedimentary rock such that layers are at angles to rather than parallel to the other layers.

Damping. A resistance to vibration that causes progressive reduction of motion with time or distance.

Deformation of rocks. A change in the original form or volume of rock masses produced by faulting, folding or other tectonic forces.

* From "The Seismic Safety Study," (A joint planning study of the Cities of El Cerrito, Richmond and San Pablo, Calif.)

Detritus. The materials that result from the breaking up, disintegration and wearing away of minerals and rocks resulting in alluvial deposits.

Diatomite. A light friable, siliceous material chiefly produced from the remains of minute forms of algae.

Differential Settlement. Loss of strength or the loss of water and sand through liquefaction often does not occur evenly over broad areas. Thus the ground settles different amounts in adjacent spots. Can be very destructive to buildings.

Dip. See "attitude".

Dip slip. Fault displacement parallel to the dip of the fault. See "attitude" and "slip".

Displacement. The dislocation of one side of a fault relative to the other side resulting from fault movement.

Earth-flow. A slow flow of earth lubricated with water. Earth-flows may be discriminated from earth-slumps by reason of their greater mobility.

Earthquake. Perceptible trembling to violent shaking of the ground, produced by sudden displacement of rocks below and at the earth's surface.

Earthquake focus. See "focus".

Earth-slump. See "earth-flow".

Elastic limit. The maximum stress that a material can withstand without undergoing permanent deformation either by solid flow or by rupture.

Elasticity. The property or quality of being elastic, that is, an elastic body returns to its original form or condition after a displacing force is removed.

Eocene. An epoch of the lower Tertiary period. It ranges from 37 to 38 million to 53 to 54 million years before the present.

Epicenter. The geographical location of the point on the surface of the earth that is vertically above the earthquake focus.

Fan, alluvial. See "alluvial fan".

Fault. An earth fracture or zone of fracture along which the rocks on one side have been displaced in relation to those of the other.

Fault block. A body of rock bounded by one or more faults.

Fault creep. Very slow periodic or episodic movement along a fault trace unaccompanied by quakes.

Fault-scarp. The cliff formed by a fault. Most fault scarps have been modified by erosion since faulting.

Fault set. Two or more parallel faults within an area.

Fault slip or slippage. The relative displacement of formerly adjacent points on opposite sides of a fault. Also known as fault creep.

Fault system. Two or more fault sets formed at the same time.

Fault surface. The surface along which dislocation has taken place.

Fault trace. The intersection of a fault and the earth's surface as revealed by dislocation of fences, roads, by ridges and furrows in the ground, etc.

Fault zone. A fault instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide; the fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia or other material.

Fault, active. See "active fault".

Fault, inactive. See "inactive fault".

Fault, normal. See "normal fault".

Fault, reverse. See "reverse fault".

Fault, right-lateral. See "right-lateral fault".

Fault, thrust. See "thrust fault".

Faulting. The movement which produces relative displacement of adjacent rock masses along a fracture.

Fissure. An extensive crack, break, or fracture in the rocks.

Flexuring. Synonymous with folding.

Focal depth. Depth of an earthquake focus below the ground surface.

Focus. The point within the earth which marks the origin of the elastic waves of an earthquake.

Fold. A bend in rock strata.

Formation. A rock body or an assemblage of rocks which have some character in common; applied to a particular sequence of rocks formed during one epoch; a rock unit used in mapping.

Fracture. Breaks in rocks due to intense faulting or folding.

Free face. A sloping surface exposed to air or water such that there is little or no resistance to lateral movement of earth materials.

Frequency. The number of seismic wave peaks which pass through a point in the ground in a unit of time. Usually measured in cycles per second.

Friable. A term applied to rocks that are easily crumbled or pulverized.

Geodetic measurements. Controls on location (vertical & horizontal) of positions on the earth's surface of a high order of accuracy, usually extended over large areas for surveying and mapping operations.

Geology. The science which treats of the earth, the rocks of which it is composed, and the changes which it has undergone or is undergoing.

Geophysical surveys. The use of one or more physical techniques to explore earth properties and processes.

Gouge material. Finely ground material occurring between the walls of a fault, the result of grinding movements.

Graywacke. A hard, dark-colored, sandstone composed primarily of highly angular quartz and feldspar in a clay matrix. Usually contains significant quantities of rock fragments.

Ground cracking. Cracks usually occurring in stiff surface materials resulting from differential ground movement.

Ground failure. A situation in which the ground does not hold together such as in landsliding, mud flows, liquefaction and the like.

Ground lurching. Undulating waves in soft saturated ground that may or may not remain after the earthquake.

Ground strength. The limiting stress that ground can withstand without failing by rupture or continuous flow.

Ground response. The reaction of the ground to earthquake shaking.

Group. A local subdivision of a series of rocks, based on lithologic features. It usually contains two or more formations.

Hayward fault. A large and active branch of the San Andreas Fault System. It has been the center of many earthquakes, including the 1868 earthquake which was one of the largest ever to hit Northern California.

Hummocky. Lumpy land, or in small uneven knolls. This condition is a sign of previous extensive landsliding.

Hypocenter That point within the earth which is the center of an earthquake and the origin of its elastic waves.

Inactive faults. Identifiable faults which do not meet any of the criteria listed under "active faults".

Incompetent beds. Opposite of competent beds.

Inelastic deformation. Permanent deformation of materials either by flow, creep, or rupture.

Intensity. (See Table 1) A nonlinear measure of earthquake size at a particular place as determined by its effect on persons, structures, and earth materials. The principal scale used in the United States today is the Modified Mercalli, 1956 version. Intensity is a measure of effects as contrasted with magnitude which is a measure of energy. They are not the same.

Interstitial water. Water contained within the minute pores or spaces between the small grains or other units of rock.

Intrusion. An igneous rock that has been injected into older rocks; it has cooled and solidified from a molten condition under the cover of the surrounding rock mass.

Inundation. Flooding caused by water topping a dam or water released by dam, reservoir, levy or other break.

Isoseismic line. An imaginary line connecting all points on the surface of the earth where an earthquake shock is of the same intensity.

Lacustrine. Formed in a lake.

Landsliding. The perceptible downward sliding or falling of a relatively dry mass of earth, rock, or mixture of the two. Often loosely used to also include sliding of wet earth masses such as mudslides and earthflows.

Left-lateral fault movement. Generally horizontal movement in which the block across the fault from an observer has moved to the left.

Lenticular. Shaped approximately like a double convex lens. When a mass of rock thins out from the center to a thin edge all around, it is said to be lenticular in form.

Liquefaction. A process by which a water saturated sand loses coherence when shaken. Involved is the collapse of sand grains into intergranular voids which induces an increase in pore pressure and loss of strength. This loss of strength leads to a quicksand condition in which objects can either sink or float depending on their density.

Lithology. The description of rock composition and texture from observation of hand specimens or outcrops.

Mafic pyroclastic rocks. Pyroclastic rocks containing a high proportion of dark colored (mafic) rock and mineral constituents such as basalt.

Magnitude. The rating of a given earthquake is defined as the logarithm of the maximum amplitude on a seismogram written by an instrument of specified standard type at a distance of 62 miles from the epicenter. It is a measure of the energy released in an earthquake. The zero of the scale is fixed arbitrarily to fit the smallest recorded earthquakes. The scale is open ended but the largest known earthquake magnitudes are near 8-3/4. Because the scale is logarithmic, every upward step of one magnitude unit means a 32 fold increase in energey release. Thus, a magnitude 7 earthquake releases 32 times as much energy as a magnitude 6 earthquake. Magnitude is not the same as intensity.

Melange. A mixture or complex of rocks.

Micro-earthquake. A very small earthquake having a magnitude of 2 or less on the Richter scale.

Microseismic Event. An earthquake or man-induced vibrations observable only with instruments.

Miocene. An epoch of the upper Tertiary period. It ranges from 12 million to 26 million years before the present.

Modified Mercalli. See "intensity".

Monitoring fault movement. Use of survey methods over a period of time to measure displacement caused by creep over a period of time.

Morphology, slope. See "slope morphology."

Mudflow or mudslide. A flowage of heterogeneous debris lubricated with a large amount of water.

Normal fault. Vertical movement along a sloping fault surface in which the block above the fault has moved downward relative to the block below.

Period, natural. See "natural period".

Period, predominant. See "predominant period".

Physiography. A description of existing nature as displayed in the surface arrangement of the globe, its features, atmospheric and oceanic currents, climate, etc.

Plastic deformation. Under some conditions solids may bend instead of shearing or breaking as a result of seismic and geologic forces.

Pliocene. The latest epoch in the Tertiary period. It ranges from 7 to 10 million to 2 to 3 million years before the present.

nding. — Accumulation of alluvial and colluvial deposits behind a fault-produced barrier.

ecipitate. — The material resulting from the process of separating mineral constituents from a solution by evaporation (salt, etc.) or from magma to form igneous rocks.

edominant riod. — A number representing the time between seismic wave peaks to which a building on the ground is most vulnerable. Usually measured in seconds.

mice. — An excessively cellular, glassy lava of whitish or gray color. It is very light and will float on water.

roclastic. — A general term for fragmental deposits of volcanic materials, including volcanic conglomerate, agglomerate, tuff and ash.

mote nsing. — The acquisition of information or measurement of some property of an object by a recording device that is not in physical or intimate contact with the object under study. The technique employs such devices as the camera, lasers, infrared and ultraviolet detectors, microwave and radio frequency receivers, radar systems, etc.

sidual soil. — A soil deposit formed by the decay of rock in place.

verse or ust fault. — Vertical or nearly horizontal movement along a sloping fault surface in which the block above has moved upward or over the block below the fault.

ht-lateral lt vement. — Generally horizontal movement in which the block across the fault from an observer has moved to the right.

ponds. — Ponds occupying depressions along active faults. The depressions are due to uneven settling of the ground.

d boils. — Turgid upward flow of water and some sand to the ground surface resulting from increased ground water pressures when saturated cohesionless materials are compacted by earthquake ground vibrations.

rp. — An escarpment, cliff, or steep slope of some extent along the margin of a plateau, terrace, bench, and at the top of a slide.

iment. — Solid material settled from suspension in a liquid.

imentary ks. — Rocks, commonly stratified, formed by the accumulation of sedimentation in water or from air.

smograph. — An instrument that writes a permanent continuous record of earth vibrations.

smic. — Pertaining to an earthquake or earth vibration, including those that are artificially induced.

smology. — The science of earthquakes and related phenomena.

smometer. — A device which detects vibrations of the earth, and whose physical constants are known sufficiently for calibration to permit calculation of actual ground motion from the seismograph.

ear. — A mode of failure whereby two adjacent parts of a solid, slide past one another parallel to the plane of contact. To subject a body to shear, similar to the displacement of the cards in a pack relative to one another.

Slip, fault. — See "fault slip".

Solid flow. — Flow of a solid under long-time stress.

Strata. — Layers of sedimentary rocks.

Strength, ground. — See "ground strength".

Strike. — See "attitude".

Strike-slip. — Fault displacement parallel to the strike of the fault. See "attitude" and "slip".

Strong motion. — Ground motion produced by a "strong" earthquake or one capable of producing damage to structures. The magnitude of such an earthquake may vary considerably according to the character of the earthquake.

Structural feature. — Features produced in the rock by movements after deposition, and commonly after consolidation, of the rock.

Subsidence. — A shrinking of a large area of land, usually observed as a shrinkage.

Surface wash. — A loose surface deposit of sand, gravel, boulders, etc.

Syncline. — A trough-shaped fold in rocks in which the strata dip inward from both sides toward the axis. The opposite of anticline.

Tectonic. — Pertaining to or designating the rock structure and external forms resulting from the deformation of the earth's crust. Pressures causing such deformations often result in earthquakes.

Trace, fault. — See "fault trace".

Thrust fault. — See "reverse fault".

Topography. — The physical features of the land, especially its relief and contour.

Torsional forces. — Forces which act to twist the object in question.

Tsunami. — A sea wave produced by large areal displacements of the ocean bottom, often the result of earthquakes or volcanic activity. Also known as seismic sea waves.

Unconformity. — In sedimentary rocks sometimes strata of intermediate age between younger and older rocks are absent. This is usually caused by total erosion of the middle-aged sediment before the younger sediment was deposited.

Unconsolidated material. — Opposite of "consolidated material".

Undulating waves. — Waves that rise and fall.

Water Table. — The upper surface of a zone of water saturation within the ground.

Wash, surface. — See "surface wash".

Wave height. — The difference in elevation between adjoining wave crests and troughs.

APPENDIX II

OPTIONS MATRIX

A list of rather specific options were provided with each hazard discussed. These represent only a fraction of the possible responses to a hazardous situation. The Options Matrix is designed to expand upon the previous offerings by illustrating a methodology for evolving additional options.

Following an assessment of the hazard and determination that some action should be taken, the first step in using the matrix is to identify the resources affected by a hazard and select those which are to be addressed. The second step is to choose an appropriate response to the situation in question. The Matrix offers a range of resources and responses.

Before one can actually formulate an option or recommendation, one must also consider such things as: which hazard zone (high, moderate, low) should be addressed, the use of various qualifiers (all, most, some, etc.) and the time period for implementation. Some examples of recommendations in the form of policy statements derived from the Matrix follow:

> All permanent structures for human habitation located in high hazard zone (within 25 feet of the fault trace of an active fault) shall be removed within ten (10) years.
>
> All property owners within the high and moderate hazard zones shall be notified of the existence and potential extent of the ground shaking hazard within one year of the adoption of this policy.

OPTIONS MATRIX

RESPONSES: Remove	Prohibit	Limit	Discourage	Inpsect for deficiencies	Up-grade to code	Warn of hazarous condition	Further study	Up-grade code	Review & practice warning plans	RESOURCES
										Structures
										Structures for human habitation
										Multiple dwelling units
										High temporary concentrations of people
										Public buildings and facilities
										Vital public services (police, fire, water, etc.)
										Sensitive facilities (hospitals, resthomes)
										High risk facilities (oil storage, chemical)

Other Considerations:

1. Qualifiers of Resources: all, some, most,
2. Time period of implementation: immediately, in 6 months,
3. Which hazard zone: high, medium and low.

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RESOLUTION NO. 87-364

A RESOLUTION OF THE MOORPARK CITY COUNCIL OF THE CITY OF MOORPARK, CALIFORNIA, ADOPTING THE SAFETY ELEMENT OF THE GENERAL PLAN OF SAID CITY.

WHEREAS, a Draft Safety Element has been prepared for the City of Moorpark, on file in the office of the City Clerk, designated as Exhibit A, and incorporated herein by reference; and

WHEREAS, the Planning Commission held public hearings on October 8, 1986 and October 22, 1986, to review input during the preparation of said Draft Safety Element; and

WHEREAS, the Planning Commission considered the Draft Safety Element on October 22, 1986, and at that time, recommended with changes, approval of the Draft Safety Element to the City Council for adoption; and

WHEREAS, the City Council has reviewed and considered on December 8, 1986, the Draft Safety Element as recommended by the Planning Commission and has held a public hearing to receive public input to the draft element;

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF MOORPARK, CALIFORNIA, DOES RESOLVE AS FOLLOWS:

SECTION 1. The City Council hereby finds and determines that the General Plan Safety Element will not have a significant effect on the environment and that the Negative Declaration is to be filed with the Clerk of the County of Ventura; and

SECTION 2. The City Council hereby adopts this Safety Element (Exhibit A, herein above referred to), as an officially adopted element of the General Plan of the City of Moorpark.

SECTION 3. The City Clerk shall certify to the adoption of this resolution and shall cause this resolution and his certification to be filed in the office of the City Clerk.

BE IT FURTHER RESOLVED, that this resolution shall take effect immediately; and

BE IT FURTHER RESOLVED, that the City Council shall certify to the passage and adoption of this resolution.

PASSED, APPROVED AND ADOPTED this 7th day of January, 1987.

Mayor of the City of Moorpark, CA.

ATTEST:

Maureen W. Wall

City Clerk

(SEAL)

STATE OF CALIFORNIA)
COUNTY OF VENTURA)
CITY OF MOORPARK)

I, Maureen W. Wall, City Clerk of the City of Moorpark, California, do hereby certify that the foregoing Resolution No. 87-364 was adopted by the City Council of the City of Moorpark, at their meeting of January 7, 1987, and that the same was adopted by following vote, to wit:

AYES: Councilmembers Eloise Brown, Clint Harper, John Galloway, Danny Woolard, and Mayor Thomas Ferguson

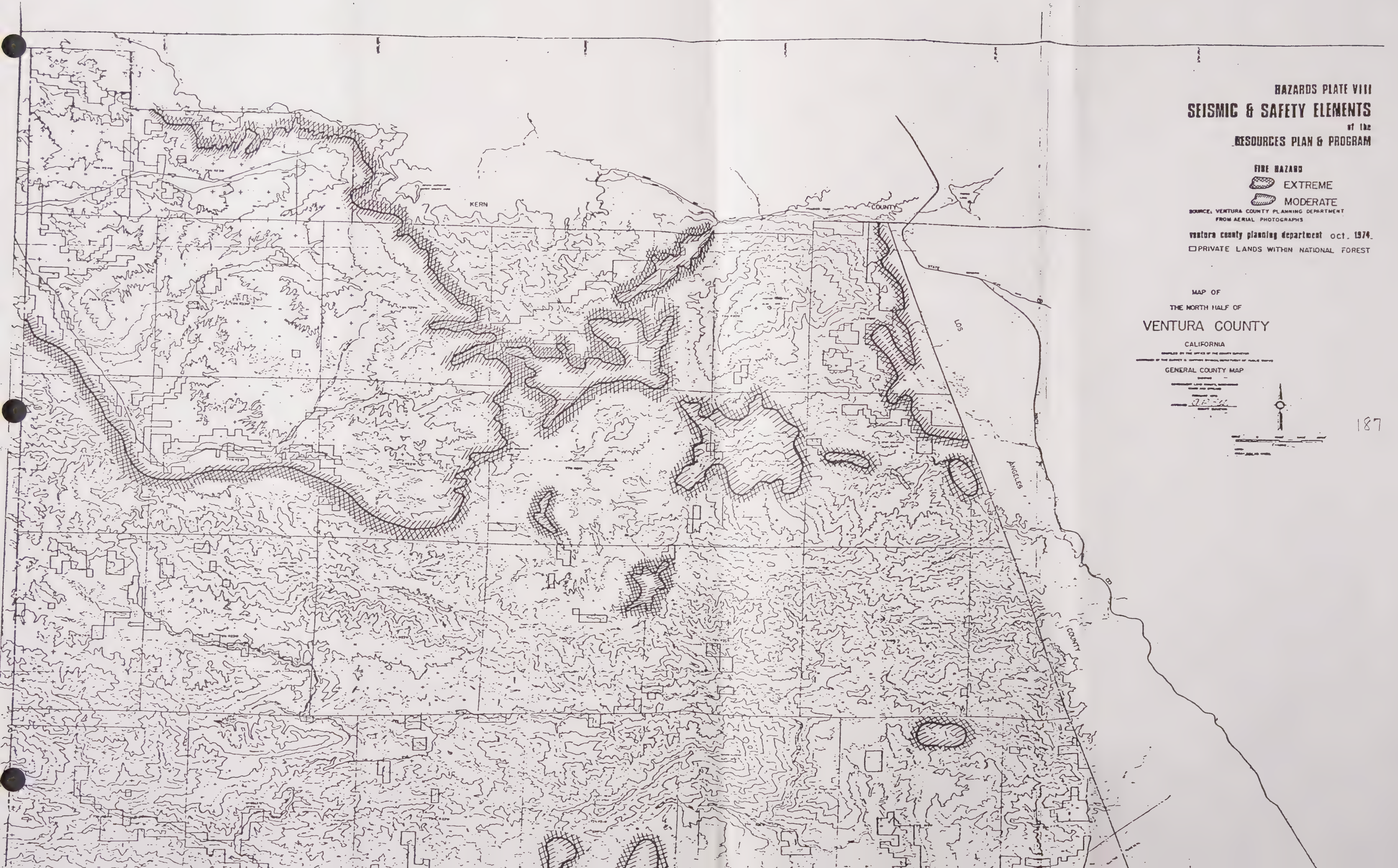
NOES: None

ABSENT: None

WITNESS my hand and the official seal of said City this 8th day of January, 1987.

Maureen W. Wall
City Clerk, Moorpark, California

(SEAL)


HAZARDS PLATE VIII
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
FIRE HAZARD
EXTREME
MODERATE
SOURCE: VENTURA COUNTY PLANNING DEPARTMENT
FROM AERIAL PHOTOGRAPHS
ventura county planning department oct. 1974
PRIVATE LANDS WITHIN NATIONAL FOREST
MAP OF
THE NORTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP
KERN
COUNTY
LOS
ANGELES
COUNTY
STATE

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HAZARDS PLATE VIII

SEISMIC & SAFETY ELEMENTS of the RESOURCES PLAN & PROGRAM

prepared by

ventura county planning department october 1974

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SANTA BARBARA COUNTY
LOS ANGELES COUNTY
FILLMORE
SANTA PAULA
RANCHO SAN FRANCISCO
PACIFIC OCEAN
SAN BUENAVENTURA
SIMI VALLEY
CAMARILLO
THOUSAND OAKS
OXNARD
PORT HUENEME
liquefaction potential*
high - water table less than 15' from surface
moderate - water table 15' to 40' from surface
water bodies subject to seiche*
tsunami hazard zone*
source:
• ventura county department of public works
- ventura county planning department
HAZARDS PLATE V
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
prepared by
ventura county planning department
october, 1974
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP

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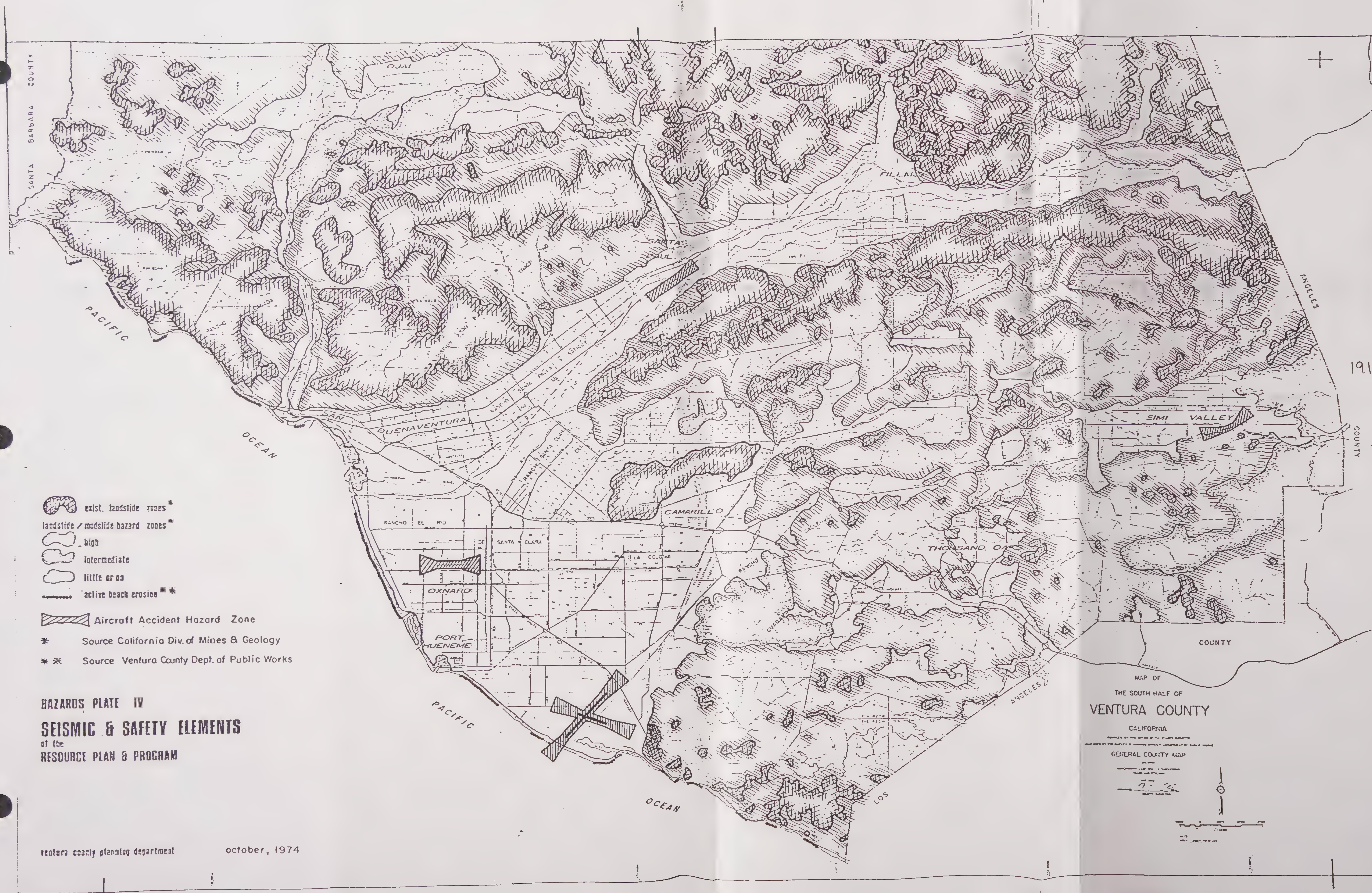
EXPANSIVE SOIL ZONES
high
moderate
low
PROBABLE SUBSIDENCE ZONES
approximately 0.05'/yr.
less than 0.05'/yr.
estimated limit
HAZARDS PLATE VI
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
ventura county planning department
october, 1974
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP
SANTA BARBARA COUNTY
LOS PADRES NATIONAL FOREST
BOUNDARY
FILLMORE
SANTA PAULA
SAN BUENAVENTURA
SIMI VALLEY
CAMARILLO
OXNARD
PORT HUENEME
PACIFIC OCEAN
LOS ANGELES COUNTY
190



SANTA BARBARA COUNTY
OJAI
FILLMORE
SANTA PAULA
PACIFIC
OCEAN
SAN BUENAVENTURA
CAMARILLO
SIMI VALLEY
THOUSAND OAKS
ANGELES
COUNTY
LOS ANGELES
RANCHO EL RIO
SANTA CLARA
LA COLONIA
OXNARD
PORT HUENEME
PACIFIC
OCEAN
exist. landslide zones*
landslide / mudslide hazard zones*
high
intermediate
little or no
active beach erosion**
Aircraft Accident Hazard Zone
* Source California Div. of Mines & Geology
** Source Ventura County Dept. of Public Works
HAZARDS PLATE IV
SEISMIC & SAFETY ELEMENTS
of the
RESOURCE PLAN & PROGRAM
ventura county planning department
october, 1974
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP


SANTA BARBARA COUNTY
OJAI
FILLMORE
SANTA PAULA
SAN BUENAVENTURA
PACIFIC OCEAN
OXNARD
PORT HUENEME
THOUSAND OAKS
SIMI VALLEY
CAMARILLO
LOS ANGELES COUNTY
PACIFIC OCEAN
selected channels †
designated flood plains
standard project *
intermediate regional (100 year) *
area possibly subject to 50 year ††
* source: u.s. army corps of engineers
† source: ventura county flood control district
†† source: u.s.d.a. soil conservation service
HAZARDS PLATE III
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGAM
ventura county planning department
october, 1974
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP

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POTENTIAL AMPLIFICATION OF GROUND SHAKING
A long period—greatest
B long period—slight to moderate
C short period—greatest
D short period—slight to moderate
E relatively low
SOURCE: VENTURA COUNTY DEPARTMENT OF PUBLIC WORKS
HAZARDS PLATE II
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
ventura county planning department october 1974
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP
SANTA BARBARA
PACIFIC
OCEAN
PACIFIC
OCEAN
OJAI
FILLMORE
SANTA PAULA
BUENAVENTURA
OXNARD
PORT HUENEME
CAMARILLO
THOUSAND OAKS
SIMI VALLEY
SAN FRANCISCO
LOS ANGELES
LOS ANGELES
LOS ANGELES COUNTY
COUNTY
RANCHO EL RIO
LA COLONIA
CALLEGUAS
GUADALASCA
LAS POSAS
RANCHO

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HAZARDS PLATE II

SEISMIC & SAFETY ELEMENTS

of the

RESOURCES PLAN & PROGRAM

ventura county planning department may, 1974.

october 1974

MAP OF

THE NORTH HALF OF

VENTURA COUNTY

CALIFORNIA

GENERAL COUNTY MAP

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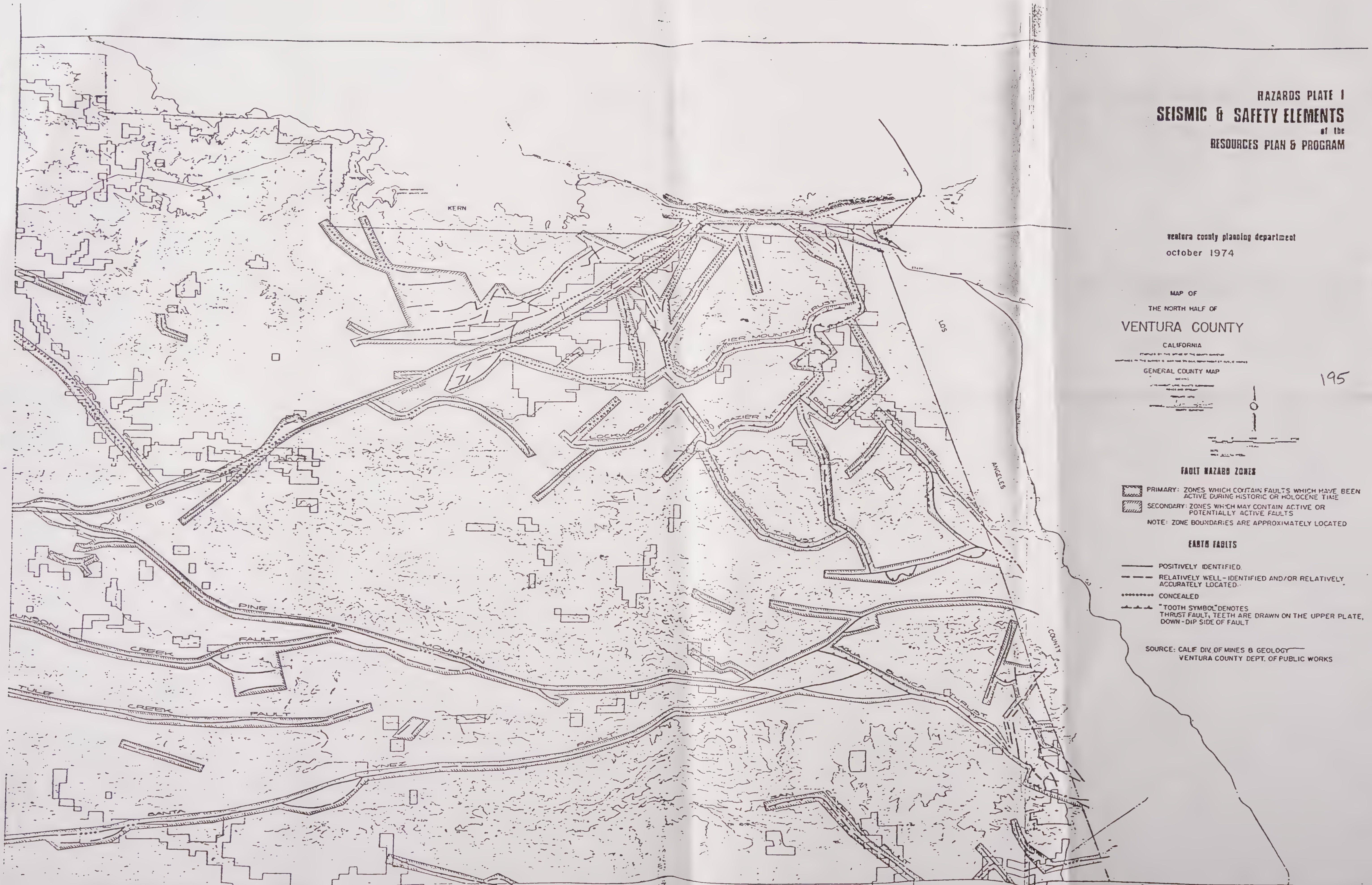
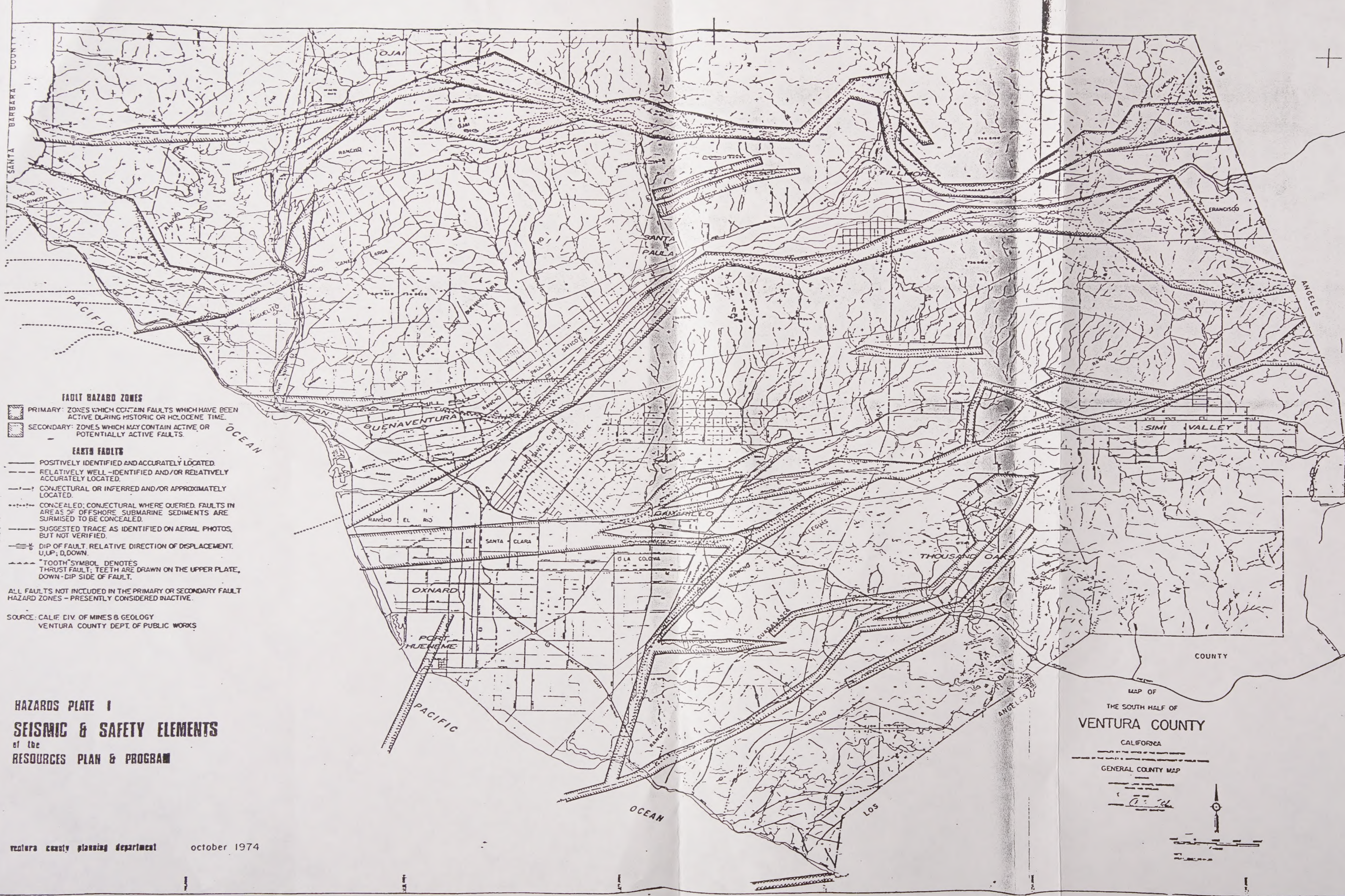
POTENTIAL AMPLIFICATION OF GROUND SHAKING

- A LONG PERIOD-GREATEST
- B-C SHORT PERIOD-GREATEST
- D SHORT PERIOD-SLIGHT TO MODERATE
- E RELATIVELY LOW

SOURCE: VENTURA COUNTY DEPARTMENT OF PUBLIC WORKS

- PRIVATE LANDS WITHIN NATIONAL FOREST


HAZARDS PLATE I
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
ventura county planning department
october 1974
MAP OF
THE NORTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP
195
FAULT HAZARD ZONES
PRIMARY: ZONES WHICH CONTAIN FAULTS WHICH HAVE BEEN ACTIVE DURING HISTORIC OR HOLOCENE TIME
SECONDARY: ZONES WHICH MAY CONTAIN ACTIVE OR POTENTIALLY ACTIVE FAULTS
NOTE: ZONE BOUNDARIES ARE APPROXIMATELY LOCATED
EARTH FAULTS
POSITIVELY IDENTIFIED.
RELATIVELY WELL-IDENTIFIED AND/OR RELATIVELY ACCURATELY LOCATED.
CONCEALED
"TOOTH SYMBOL" DENOTES THRUST FAULT, TEETH ARE DRAWN ON THE UPPER PLATE, DOWN-DIP SIDE OF FAULT
SOURCE: CALIF. DIV. OF MINES & GEOLOGY
VENTURA COUNTY DEPT. OF PUBLIC WORKS
KERN
LOS ANGELES
COUNTY
FRAZIER MOUNTAIN THRUST
FRAZIER MT. THRUST
LOCKWOOD FAULT
SAN GABRIEL FAULT
BIG PINE
PINE MOUNTAIN
FAULT
MUNSON CREEK FAULT
TULE CREEK FAULT
SANTA YNEZ FAULT
SAN CAYETANO THRUST



FAULT HAZARD ZONES
PRIMARY: ZONES WHICH CONTAIN FAULTS WHICH HAVE BEEN ACTIVE DURING HISTORIC OR HOLOCENE TIME.
SECONDARY: ZONES WHICH MAY CONTAIN ACTIVE OR POTENTIALLY ACTIVE FAULTS.
EARTH FAULTS
POSITIVELY IDENTIFIED AND ACCURATELY LOCATED.
RELATIVELY WELL-IDENTIFIED AND/OR RELATIVELY ACCURATELY LOCATED.
CONJECTURAL OR INFERRED AND/OR APPROXIMATELY LOCATED.
CONCEALED; CONJECTURAL WHERE QUERIED. FAULTS IN AREAS OF OFFSHORE SUBMARINE SEDIMENTS ARE SURMISED TO BE CONCEALED.
SUGGESTED TRACE AS IDENTIFIED ON AERIAL PHOTOS, BUT NOT VERIFIED.
DIP OF FAULT. RELATIVE DIRECTION OF DISPLACEMENT. U,UP; D,DOWN.
"TOOTH" SYMBOL DENOTES THRUST FAULT; TEETH ARE DRAWN ON THE UPPER PLATE, DOWN-DIP SIDE OF FAULT.
ALL FAULTS NOT INCLUDED IN THE PRIMARY OR SECONDARY FAULT HAZARD ZONES - PRESENTLY CONSIDERED INACTIVE.
SOURCE: CALIF. DIV. OF MINES & GEOLOGY
VENTURA COUNTY DEPT. OF PUBLIC WORKS
HAZARDS PLATE I
SEISMIC & SAFETY ELEMENTS
of the
RESOURCES PLAN & PROGRAM
ventura county planning department
october 1974
SANTA BARBARA COUNTY
OJAI
FILLMORE
SANTA PAULA
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OXNARD
PORT HUENEME
CAMARILLO
PACIFIC OCEAN
LOS ANGELES COUNTY
MAP OF
THE SOUTH HALF OF
VENTURA COUNTY
CALIFORNIA
GENERAL COUNTY MAP

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